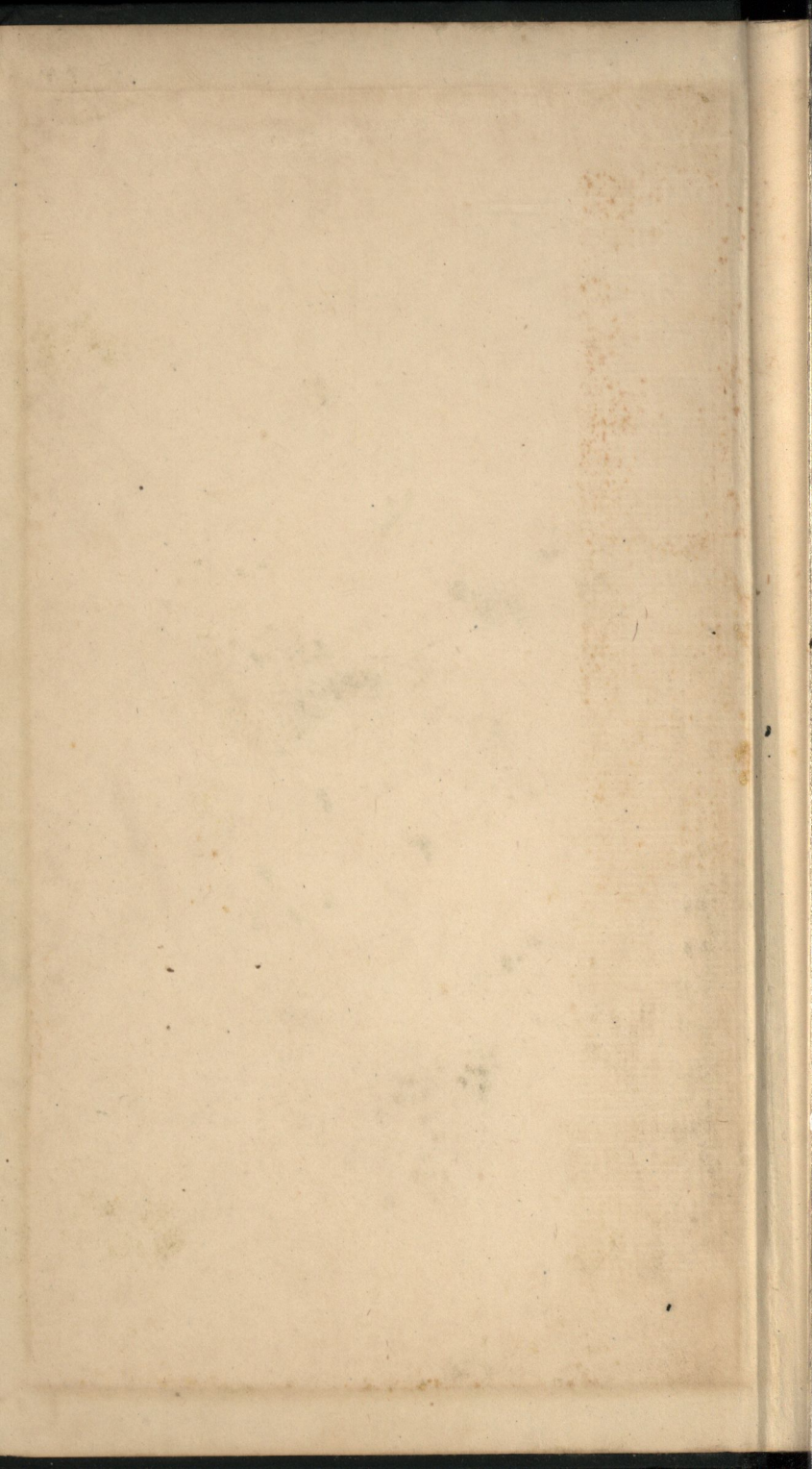




6^a
①

DEPARTMENT OF COMMERCE
W. AVERELL HARRIMAN, *Secretary*
CIVIL AERONAUTICS ADMINISTRATION
T. P. WRIGHT, *Administrator*

STANDARD SPECIFICATIONS
FOR
CONSTRUCTION
OF
AIRPORTS



OFFICE OF AIRPORTS
WASHINGTON, D. C.

January 1948

DEPARTMENT OF COMMERCE
W. AVERRELL HARRIMAN, Secretary
CIVIL AERONAUTICS ADMINISTRATION
T. P. WRIGHT, Administrator

STANDARD SPECIFICATIONS
FOR
CONSTRUCTION
OF
AIRPORTS



OFFICE OF AIRPORTS
WASHINGTON, D. C.

January 1948

CONTENTS

DIVISION I. GENERAL PROVISIONS

FOREWORD

The specification items contained in this book are for the construction of airports and airparks in the United States, its territories and possessions. Items covered are clearing and grubbing, grading, drainage, paving, lighting, turfing, and incidental construction items.

This book, when cited in the contract, shall be considered as a contract document and shall be binding in its entirety upon the parties signatory to the contract, except that such specification items as are not cited or involved in the plans, bid schedule, special provisions, or other contract documents shall not be a part of the particular contract; also any item contained herein which is modified by or is in conflict with, any supplemental specifications, or special provisions shall not be binding for the particular contract.

This book contains articles on patents, liquidated damages, qualifications of bidders, and provides certain administrative procedures for partial payments. Included are certain clauses to be mutually agreed upon covering administrative procedures in handling the work and any contingencies encountered.

H. ARTHUR HOOK,

Assistant Administrator for Airports.

III

FENCES

P-160	Wire Fence With Wood Posts (Classes "A" and "B")	71
P-161	Wire Fence With Steel Posts (Classes "C" and "D")	77
P-162	Chain Link Fence (Class "E")	82
P-163	Wood Post-and-Rail Fence (Class "F")	89

FLEXIBLE BASE COURSES

P-201	Bituminous Base Course	93
P-204	Mixed In-Place Base Course	108
P-205	Dry-Bound Macadam Base Course	119
P-206	Water-Bound Macadam Base Course	125
P-208	Aggregate Base Course	131
P-209	Crushed Aggregate Base Course	141

FOREWORD

NOTE TO SPONSORS

The specification items contained in this book are of necessity general in scope. Inherent local conditions, practices, and needs may require the modification or alteration of some items to make them consistent with local requirements. The sponsor of the project, his representative, and a CAA district engineer can best judge the local requirements for modifications or alterations. No attempt has been made to include any modification in this book as they can be best evaluated by the sponsor. In similar manner the sponsor may add additional items to satisfy special local requirements.

This page will not be considered as a part of any contract.

CONTENTS

DIVISION I—GENERAL PROVISIONS

Section		Page
10	Definition of Terms.....	1
20	Proposal Requirements and Conditions.....	6
30	Award and Execution of Contract.....	10
40	Scope of Work.....	12
50	Control of Work and Materials.....	15
60	Legal Relations and Responsibilities to Public.....	20
70	Prosecution and Progress.....	24
80	Measurement and Payment.....	30

DIVISION II—CONSTRUCTION MATERIALS

90	Paving Material Details.....	34
91	Turfing Material Details.....	42
92	Lighting Material Details.....	45

DIVISION III—PAVING CONSTRUCTION DETAILS

EARTHWORK

Item		
P-151	Clearing and Grubbing.....	50
P-152	Excavation and Embankment.....	53
P-153	Watering.....	64
P-154	Subbase Course.....	65

FENCES

P-160	Wire Fence With Wood Posts (Classes "A" and "B").....	71
P-161	Wire Fence With Steel Posts (Classes "C" and "D").....	77
P-162	Chain Link Fences (Class "E").....	82
P-163	Wood Picket Fences (Class "F").....	89

FLEXIBLE BASE COURSES

P-201	Bituminous Base Course.....	93
P-204	Mixed In-Place Base Course.....	108
P-205	Dry-Bound Macadam Base Course.....	119
P-206	Water-Bound Macadam Base Course.....	125
P-208	Aggregate Base Course.....	131
P-209	Crushed Aggregate Base Course.....	141

Item		Page
P-210	Caliche Base Course.....	148
P-211	Lime Rock Base Course.....	156
P-212	Shell Base Course.....	162
P-213	Sand-Clay Base Course.....	169
P-214	Penetration Macadam Base Course.....	176
P-215	Emulsified Asphalt Aggregate Base Course.....	184
P-216	Mixed In-Place Base Course.....	197
P-217	Aggregate—Turf Pavement.....	208

RIGID BASE COURSES

P-301	Soil Cement Base Course.....	216
P-302	Lean Mix Rolled Concrete Base Course.....	224

FLEXIBLE SURFACE COURSES

P-401	Bituminous Surface Course.....	233
P-405	Key Stone Mat Course.....	248
P-408	Blended Natural Limestone & Sand Asphalt Surface.....	255
P-410	Asphalt Concrete Surface Course.....	268
P-411	Surface Treatment With Limestone and Sand Asphalt Mixture.....	280

RIGID PAVEMENT

P-501	Portland Cement Concrete Pavement.....	288
-------	--	-----

MISCELLANEOUS

P-602	Bituminous Prime Coat.....	315
P-603	Bituminous Tack Coat.....	318
P-604	Bituminous Seal Coat.....	322
P-605	Joint Sealing Filler.....	327
P-609	Bituminous Surface Treatment.....	332
P-610	Structural Portland Cement Concrete.....	341
P-612	Admixtures.....	353

DRAINAGE PIPE

D-701	Clay Pipe for Storm Sewers and Culverts.....	357
D-702	Concrete Pipe for Storm Sewers and Culverts.....	363
D-703	Corrugated Metal Pipe, Galvanized, or Galvanized and Bituminous-Coated, for Storm Sewers and Culverts.....	369
D-704	Cast Iron Pipe for Storm Sewers and Culverts.....	375
D-705	Pipe Underdrains for Airports.....	381

DRAINAGE STRUCTURES

D-751	Manholes, Catch Basins, Inlets, and Inspection Holes.....	390
D-752	Concrete Culverts, Headwalls, and Miscellaneous Drainage Structures.....	397

Item		Page
D-753	Cement Rubble Masonry Culverts, Headwalls, and Miscellaneous Drainage Structures.....	401
D-754	Concrete Paved Gutters, Ditches, and Flumes.....	407
D-755	Grouted Rubble Gutters, Ditches, and Flumes....	410

DIVISION IV—TURFING

T-901	Seeding.....	412
T-902	Seeding (Modified).....	421
T-903	Sprigging.....	426
T-904	Sodding.....	435
T-905	Topsoiling.....	443
T-906	Topsoil Planting.....	447
T-907	Tilling.....	455
T-908	Mulching.....	457
T-950	Planting Trees, Shrubs, and Vines.....	460
T-951	Tree Wells and Root Protection.....	469

DIVISION V—LIGHTING INSTALLATION

L-101	Airport 36-inch Rotating Beacon.....	472
L-102	Airport Code Beacon.....	477
L-103	Airport Beacon Towers.....	481
L-104	Airport Flush Marker Lights.....	486
L-105	Airport Cone-Mounted Lights for Series Circuits...	491
L-106	Airport Obstruction Lights.....	496
L-107	Airport 12-foot Wind Cone.....	502
L-108	Airport Underground Cable for Large Airports.....	505
L-109	Airport Transformer Vault and Equipment.....	511
L-110	Airport Underground Electrical Duct.....	521
L-111	Airport Building Wiring.....	526
L-112	Airport Wind Tee.....	533
L-113	Airport Rotating Beacon for Small Airports.....	536
L-114	Airport Elevated Marker Lights, Base-Mounted Type.....	540
L-115	Airport Elevated Marker Lights, Stake-Mounted Type.....	544
L-116	Airport Elevated Marker Lights, Column-Mounted Type.....	548
L-117	Illuminated Wind Cone for Small Airports.....	552
L-118	Airport Underground Cable for Small Airports.....	555
L-119	Airport Light-Duty Obstruction Lights.....	561
L-121	Airport High-Intensity Runway Marker Lights....	565

DIVISION VI—APPENDIX A

Test		570
T-611	Compaction Control Tests.....	578
T-607	Sand Stability Test.....	

INDEX

Index.....	581
------------	-----

DIVISION I—GENERAL PROVISIONS

SECTION 10

DEFINITION OF TERMS

10-01 DEFINITION OF TERMS. Whenever in these specifications and in the contract, or in any documents or instruments pertaining to construction where these specifications govern, the following terms are used, the intent and meaning shall be interpreted as follows:

10-02 ACCESS ROAD. The right-of-way, the roadway and all improvements constructed thereon, connecting the airport to a public highway.

10-03 ADMINISTRATOR. Administrator of Civil Aeronautics or his duly authorized representative.

10-04 AIRPORT. Airport means any area of land or water which is used, or intended for use, for the landing and take-off of aircraft, and any appurtenant areas which are used, or intended for use, for airport buildings or other airport facilities or rights-of-way, together with all airport buildings and facilities located thereon.

10-05 A. A. S. H. O. The American Association of State Highway Officials.

10-06 A. S. T. M. The American Society for Testing Materials.

10-07 BIDDER. Any individual, partnership, firm, or corporation, acting directly or through a duly authorized representative, submitting a proposal for the work contemplated.

10-08 BUILDING AREA. Building area is that part of an airport which is used, considered, or intended to be used for airport buildings or other airport facilities or rights-of-way together with all airport buildings and facilities located thereon.

10-09 CAA. Civil Aeronautics Administration of the United States Department of Commerce.

10-10 CONTRACT. The written agreement covering the performance of the work. The contract shall include the proposal, plans, specifications, special provisions, work order, contract bond, and payment bond. It shall also include any and all supplemental agreements which may be executed to complete the work, in accordance with the intent of the plans and specifications, in an acceptable manner.

10-11 CONTRACT BOND. The approved form of security furnished by the contractor and his surety as a guarantee of good faith and ability on the part of the contractor to execute the work in accordance with the terms of the plans, specifications, and contract.

10-12 CONTRACTOR. The individual, partnership, firm, or corporation executing a contract, acting directly or through his lawful agents or employees, who is primarily liable for the acceptable performance of the work for which he has contracted, and also for the payment of all legal debts pertaining to the work.

10-13 DRAINAGE. Drainage is the system of pipes, drainage-ways, ditches, and structures by which surface or subsurface waters are collected and conducted from the airport area.

10-14 ENGINEER. The engineer, duly authorized by the owner or sponsor, acting directly or through an assistant or representative.

10-15 EQUIPMENT. All machinery together with the necessary supplies for upkeep and maintenance and also all tools and apparatus necessary for the proper construction and acceptable completion of the work.

10-16 INSPECTOR. An authorized representative of the engineer assigned to make all necessary inspections of the work performed or being performed, or of the materials furnished or being furnished by the contractor.

10-17 INTENTION OF TERMS. Whenever, in these specifications or upon the plans, the words "directed," "required," "permitted," "ordered," "designated," "prescribed," or words of like import, are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription of the engineer is intended; and similarly, the words "approved," "acceptable," "satisfactory," or words of like import, shall mean approved by, or acceptable to, or satisfactory to the engineer, subject in each case to the final determination of the owner.

Any reference to a paragraph or subparagraph within a section shall include the general provision of the section or sections and paragraph pertinent thereto.

10-18 LABORATORY. The official testing laboratories of the owner or such other laboratories as may be designated by the engineer.

10-19 LANDING STRIP. A portion of the usable area of an airport, generally in its natural state or which as the result of construction work is suitable for the landing and taking off of aircraft under all ordinary weather conditions. The runway is the paved central portion of the landing strip.

10-20 LANDSCAPING. The planning, planting, establishing, and caring for trees, shrubs, vines, and other vegetation to provide shade, reduce dust, control erosion, or improve the general appearance of the airport.

10-21 LIGHTING. A system of fixtures providing or controlling the light sources used on or near the airport or within the airport buildings. The field lighting includes all luminous signals,

markers, floodlights, and illuminating devices used on or near the airport to promote visual identification of the airport or to aid in the operation of aircraft landing at, taking off from, or taxiing on the airport surface.

10-22 NOTICE OF AWARD. A written notice to the successful bidder stating that this bid has been accepted and that, in accordance with the terms of the notice to contractors and the specifications, he is required to execute the contract and furnish satisfactory contract bond.

10-23 NOTICE TO PROCEED. A written notice to the contractor of the date on which he is to begin the prosecution of the work for which he has contracted.

10-24 OWNER. The owner or sponsor is any public agency which, either individually or jointly with one or more other public agencies, submits to the Administrator, in accordance with the Federal Airport Act, an application for a grant of funds for airport development.

10-25 PAYMENT BOND. The approved form of security furnished by the contractor and his surety as a guarantee that he will pay in full all bills and accounts for materials and labor used in the construction of the work, as provided by law.

10-26 PLANS. The official plans, working drawings, or supplemental drawings or exact reproductions thereof, approved by the engineer which show the location, character, dimensions, and details of the airport and the work to be done and which are to be considered as a part of the contract, supplementary to these specifications.

10-27 PROJECT. A project for the accomplishment of airport development with respect to a particular airport.

10-28 PROPOSAL. The written offer of the bidder, when submitted on the approved proposal form, to perform the contemplated work and furnish the necessary materials in accordance with the provisions of the plans and these specifications.

10-29 PROPOSAL FORM. The approved form on which the written offer or formal bid is to be prepared and submitted for the construction to be done.

10-30 PROPOSAL GUARANTY. The security to be furnished by the bidder as a guaranty of good faith that he will enter into a contract with the owner and to execute the required bonds covering the work contemplated, if the same is awarded to him.

10-31 PUBLIC AGENCY. Public agency means the United States Government or an agency thereof; a State, the Territory of Alaska, the Territory of Hawaii, or Puerto Rico, or an agency of any of them; a municipality or other political subdivision; or a tax-supported organization.

10-32 RESIDENT ENGINEER. The representative of the owner directly in charge of the work.

10-33 RIGHT-OF-WAY. All lands or other property interests provided or acquired for the development and operation of an airport and its appurtenances.

10-34 RUNWAY. The paved surface of an airport used for the landing and taking off of aircraft.

10-35 SHOULDERS. That portion of the landing strip lying outside of runway areas.

10-36 SODDING. The transplanting of established turf in the form of blocks or strips, usually referred to as sods.

10-37 SPECIAL PROVISIONS. The specific clauses setting forth conditions or requirements peculiar to the project under consideration, covering work or materials involved in the proposal and estimate, which are not thoroughly or satisfactorily stipulated in these specifications.

10-38 SPECIFICATIONS. The directions, provisions, and requirements contained herein, supplemented by special provisions, pertaining to the method and manner of performing the work, or to the quantities, or the qualities of materials to be furnished under the contract.

10-39 STRUCTURES. As used in these specifications, structures shall mean culverts, including headwalls and endwalls, drainage construction such as storm sewers, gutters, catch basins, drop inlets, manholes, retaining walls, lighting structures and other construction which may be encountered in the building of the runways, landing strips, taxiways, and roadways.

10-40 SUBGRADE. That portion of the runway upon which the surfacing is to be placed.

10-41 SUPERINTENDENT. The executive representative for the contractor present on the work at all times during progress, authorized to receive and fulfill instructions from the engineer and capable of superintending the work efficiently.

10-42 SUPPLEMENTAL AGREEMENT. A written proposal and agreement executed by the contractor and by the owner, with the consent of the contractor's surety covering work not included in the plans and proposal or as specified in paragraph 40-03, which is necessary to the proper completion of the project.

10-43 SURETY. The corporate body or individuals who are bound by the contract bond and the payment bond with and for the contractor, and which engage to be responsible for the entire and satisfactory fulfillment of the contract and for the payment of all debts incurred in fulfilling the contract.

10-44 SURFACING. The combined subbase, base, and surface courses of pavements considered as a single unit, excluding shoulders.

10-45 TAXIWAY. A paved or unpaved strip over which aircraft may taxi to and from the landing area, runways, or aprons of an airport.

10-46 THE WORK. All work including the furnishing of materials, tools, equipment, incidentals, etc., to be performed by the contractor under the terms of the contract, plans, and specifications.

10-47 TURF. The mass of matted roots of grass and certain other low-growing plants, including the layer of soil in which they are growing and the plant growth showing above. The density and

quality of the turf mat will be influenced by environmental conditions and service requirements, but in general, maximum coverage with a minimum yield is desired, as distinct from agricultural production.

10-48 TURFING. The processes involved in the planting and development of turf, including preparation and improvement of soil, sowing or planting, cultural practices, and other operations necessary to its establishment and maintenance.

10-49 WORKING DAY. A working day shall be any day other than a legal holiday or Sunday, on which the normal working forces of the contractor may proceed with regular work for at least six (6) hours toward completion of the contract unless work is suspended for causes beyond the contractor's control. Sundays and holidays on which the contractor's forces engage in regular work, requiring the presence of an inspector, will be considered as working days.

10-50 WORKING TIME. The working time, stated in the proposal and the contract, shall be given as definite number of working days, and shall be considered an essential part of the contract.

description of the contemplated construction, the place, date, and time of opening of the proposal, and which will show the approximate quantity of the various items of work to be performed and materials to be furnished, for which unit and prices are asked. The proposal form will state the time in which the work must be completed, the amount of the proposal, and the most accurate estimate of the amount to be obtained from the various items of work to be performed and materials to be furnished in these specifications. All papers bound with or attached to the proposal forms are necessary parts thereof and must not be detached.

10-51 INTERPRETATION OF ESTIMATES. An estimate of quantities of work to be done and materials to be furnished under these specifications is given in the proposal. It is the result of careful calculation and is believed to be correct, but it is given only as a basis for comparison of proposals and the award of the contract. The owner does not expressly or by implication agree that the actual quantities involved will correspond exactly therewith; nor shall the bidder plead misunderstanding or deception because of such estimate of quantities or of the character, location or other conditions pertaining to the work. Payment to the contractor will be made only for the actual quantities of work performed or materials furnished in accordance with the plans and specifications and it is understood that the quantities may be increased or diminished as hereinafter provided without in any way affecting the unit bid prices.

10-52 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS, SITE OF WORK. The bidder is required to examine carefully the site of the proposed work, the proposed plans, specifications and contract form. He shall satisfy himself as to the character, quality, and quantity of work to be performed, materials to be furnished, and as to the requirements of these specifications.

SECTION 20

PROPOSAL REQUIREMENTS AND CONDITIONS

20-01 NOTICE TO CONTRACTORS. An official notice to contractors stating the time and place for the submission of sealed proposals upon designated projects or proposed work. This notice will contain a description of the proposed work, instructions to the bidder regarding proposal forms, proposal guaranty, plans, specifications, and the reservation of the right of the owner to reject any or all bids.

20-02 CONTENTS OF PROPOSAL FORMS. The owner will furnish bidders with proposal forms which will state the location and description of the contemplated construction, the place, date, and time of opening of the proposals, and which will show the approximate quantities of the various items of work to be performed and materials to be furnished, for which unit bid prices are asked. The proposal form will state the time in which the work must be completed, the amount of the proposal guaranty which must accompany the proposal, and will contain special provisions or requirements which vary from or are not contained in these specifications. All papers bound with or attached to the proposal forms are necessary parts thereof and must not be detached.

20-03 INTERPRETATION OF ESTIMATES. An estimate of quantities of work to be done and materials to be furnished under these specifications is given in the proposal. It is the result of careful calculations and is believed to be correct, but it is given only as a basis for comparison of proposals and the award of the contract. The owner does not expressly or by implication agree that the actual quantities involved will correspond exactly therewith; nor shall the bidder plead misunderstanding or deception because of such estimate of quantities, or of the character, location, or other conditions pertaining to the work. Payment to the contractor will be made only for the actual quantities of work performed or materials furnished in accordance with the plans and specifications and it is understood that the quantities may be increased or diminished as hereinafter provided without in any way invalidating the unit bid prices.

20-04 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS, SITE OF WORK. The bidder is required to examine carefully the site of the proposed work, the proposal, plans, specifications, and contract forms. He shall satisfy himself as to the character, quality, and quantities of work to be performed, materials to be furnished, and as to the requirements of these specifica-

tions, special provisions, and contract. The submission of a proposal shall be prima facie evidence that the bidder has made such an examination.

Any information shown on the plans as to the soil or material borings or tests of existing materials is for the convenience of the contractor. The information is not guaranteed, and no claims for extra work or damages will be considered if it is found during construction that the actual soil or material conditions vary from those indicated by the borings.

20-05 PREPARATION OF PROPOSAL. The bidder must submit his proposal on the forms furnished by the owner. All blank spaces in the proposal forms must be correctly filled in where indicated for each and every item for which a quantity is given, and the bidder must state the prices (written in ink, both in words and numerals) for which he proposes to do each item of the work contemplated or furnish each item of the materials required. In case of conflict between words and numerals, the words, unless obviously incorrect, will govern.

The bidder must sign his proposal correctly and in ink. If the proposal is offered by an individual, his name, office, and post office address must be shown. If made by a firm or partnership, the name, office, and post office address of each member of the firm or partnership must be given; if offered by a corporation, the person signing the proposal must give the name of the State under the laws which the corporation was chartered, and the name, titles, and business address of the president, secretary, and the treasurer. Anyone signing a proposal as agent must file legal evidence of his authority to do so, and that the signature is binding upon the firm or corporation.

20-06 REJECTION OF PROPOSALS. Proposals containing any omission, alterations of form, additions or conditions not called for, conditional or alternate bids unless called for, incomplete bids, or proposals otherwise regular which are not accompanied by a certified check or acceptable collateral will be considered irregular and may be rejected. The owner reserves the right to waive technicalities as to changes, alterations, or reservations, and make the award to the best interest of the owner.

20-07 PROPOSAL GUARANTY. Each separate proposal shall be accompanied by a certified check or acceptable collateral in the amount of five (5) percent of the total amount bid, made payable to the owner. A bid bond in lieu of a certified check will be acceptable.

20-08 DELIVERY OF PROPOSAL. Each proposal submitted shall be placed in a sealed envelope plainly marked with the project number, location of airport, and name and address of the bidder on the outside. When sent by mail, preferably registered, the sealed proposal, marked as indicated above, should be enclosed in an additional envelope. No proposal will be considered unless filed on or before the time and at the place designated in the advertisement or instructions to bidders.

20-09 WITHDRAWAL OF PROPOSALS. Any bidder, upon his or his authorized representative's written request, will be given permission to withdraw his proposal not later than the time set for opening thereof. At the time of opening of the proposals, when such proposal is reached, it will be returned to him unread.

20-10 PUBLIC OPENING OF PROPOSALS. Proposals will be publicly opened and read on the date and at the hour and place set in the advertisement or notice to contractors. Proposals received after the time set for the opening will be returned to the bidder unopened.

20-11 COMPETENCY OF BIDDERS. Each bidder shall furnish the owner with satisfactory evidence of his competency to perform the work contemplated. The owner reserves the right to reject a bid if the bidder has not submitted a statement of his qualifications prior to the date of the opening of the bids.

Bidders must submit their qualifications prior to the time of the opening of the bids. In making application to be placed on the qualified list, the bidders will be required to furnish a statement covering experience on similar work, a list of machinery, plant, other equipment available for proposed work, and a statement on financial resources, dated within thirty (30) days prior to the date of the opening of the bids. The owner reserves the right to make such investigation of information submitted as is deemed necessary, before a rating is given, and to disqualify any contractor from bidding if deemed in the best interest of the owner.

With each financial statement filed with the owner, as hereinbefore outlined, the bidder shall also submit a statement relating to his experience in performing construction work similar to that for which he is offering a proposal. He shall also file with the owner a statement relating to the amount and condition of his equipment as often as may be required by the owner. Both the experience and equipment statements herein referred to shall be submitted in a manner acceptable to the owner.

20-12 DISQUALIFICATION OF BIDDERS. Any one or more of the following causes may be considered as sufficient for the disqualification of bidder and the rejection of his bid or bids:

More than one proposal for the same work from an individual, firm, partnership, or corporation under the same or different names.

Evidence of collusion among bidders. Participants in such collusion may receive no recognition as bidders for any future work.

Unbalanced proposals in which the prices for some items are out of proportion to the prices for other items.

Failure to submit a unit price for each item of work for which a bid price is required by the proposal.

Lack of competency as revealed by the financial statement, experience, plant and equipment statements submitted.

Lack of responsibility as shown by past work judged from the standpoint of workmanship and progress.

Uncompleted work which, in the judgment of the owner, might hinder or prevent the prompt completion of additional work if awarded.

For being in arrears on existing contracts, in litigation with the owner, or having defaulted on a previous contract.

20-13 MATERIAL GUARANTY. Before any contract is awarded the bidder may be required to furnish a complete statement of the origin, composition, or manufacture of any or all materials proposed to be used in the construction of the work, together with samples, which may be subjected to the tests provided for in these specifications to determine their quality and fitness for the work.

20-14 REQUIREMENTS FOR FOREIGN CORPORATION, FIRM, PARTNERSHIP, OR INDIVIDUAL. Foreign corporations must conform to the statutes of the State, Territory, or possession. Before an award is made to a foreign corporation a certificate from the Secretary of State will be required by the owner, showing that such corporation is authorized to do business in the State, Territory, or possession.

SECTION 30

AWARD AND EXECUTION OF CONTRACT

30-01 CONSIDERATION OF PROPOSALS. After the proposals are opened and read, the quantities will be extended and totaled in accordance with the bid prices of the accepted proposals, and the results of the prices will be made public. Until the final award of the contract, the owner reserves the right to reject any or all proposals, to waive technicalities and to advertise for new proposals, or proceed to do the work otherwise when the best interests of the owner will be promoted thereby.

30-02 AWARD OF CONTRACT. An award of the contract will not be made until the necessary investigations are made as to the responsibility of the low bidders. Award of contract will be made by the owner, upon the recommendation of the engineer, to the lowest responsible bidder meeting the requirements of the owner, and will be made within thirty (30) days after the opening of the proposal.

30-03 RETURN OF PROPOSAL GUARANTIES. As soon as the proposal prices have been compared, the engineer may, at his discretion, return the certified checks or other collateral accompanying those proposals, which in his judgment, would not be considered in making the award. When award is made the successful bidder's collateral only will be retained until the contract and bond have been executed, after which it will be returned to the bidder. Should the award be delayed more than thirty (30) days all bidders' collateral will be returned, unless such delay is from causes beyond the control of the owner.

30-04 REQUIREMENTS OF CONTRACT BOND. The bidder to whom the contract is awarded at the time of the execution of the contract, must deposit with the owner a surety bond in sum equal to fifty (50) percent of the amount of the contract awarded, guaranteeing faithful performance of the contract. The surety shall be acceptable to the owner. The form of the bond shall be that acceptable to the owner, executed by a company licensed to do business in the State, Territory, or possession.

30-05 REQUIREMENTS OF PAYMENT BOND. The bidder to whom the contract is awarded at the time of the execution of the contract, must deposit with the owner a surety bond in sum equal to fifty (50) percent of the amount of the contract awarded, guaranteeing the payment of all labor, materials, rentals, etc. The surety shall be acceptable to the owner. The form of the bond shall be that acceptable

to the owner, executed by a company licensed to do business in the State, Territory, or possession.

30-06 EXECUTION OF CONTRACT. The individual, firm, partnership or corporation to whom or to which the contract has been awarded, shall sign the necessary agreements entering into a contract with the owner and return them to the office of the owner within ten (10) days after the contract is mailed.

30-07 APPROVAL OF CONTRACT. No contract is binding upon the owner until it has been executed by the owner and delivered to the contractor.

30-08 FAILURE TO EXECUTE CONTRACT. Failure to comply with any of the requirements of these specifications; to execute contract within ten (10) days after mailing as specified or to furnish security as required shall be just cause for the annulment of the award. In the event of such annulment of the award, the amount of proposal guaranty shall become the property of the owner, not as a penalty but as liquidated damages. Award may then be made to the next best qualified bidder, or the work re-advertised, or handled as the owner may elect.

SECTION 40

SCOPE OF WORK

40-01 INTENT OF PLANS AND SPECIFICATIONS. The intent of the plans and specifications is to prescribe a complete work or improvement which the contractor undertakes to do in full compliance with the plans, the specifications, the special provisions, proposal, and contract. The contractor shall do all work including such additional, extra, and incidental work as may be considered necessary to complete the project in a satisfactory and acceptable manner, as provided in the plans, proposal, and contract. He shall furnish, unless otherwise provided in the specifications, special provisions, or contract, all materials, equipment, tools, labor, and incidentals necessary to prosecute the completion of the work.

40-02 SPECIAL WORK. Should any construction or conditions which are not thoroughly or satisfactorily stipulated or set forth by the specification be anticipated on any proposed project, special provisions for such work may be prepared and attached to the proposal form and contract, and shall be considered as part of the specifications, the same as though contained fully therein.

40-03 CHANGES AND INCREASED OR DECREASED QUANTITIES OF WORK. The engineer reserves and shall have the right to make such changes, from time to time, in the plans, the character, or quantity of the work as may be considered necessary or desirable to complete fully and acceptably the proposed construction in a satisfactory manner, provided such alterations do not change the total cost of the project, based on the originally estimated quantities and the unit prices bid, by more than twenty-five (25) percent, and provided further that such alterations do not change the total cost of any major item, based on the originally estimated quantities and the unit price bid, by more than twenty-five (25) percent. (A major item shall be construed to be any item, the total cost of which is equal to or greater than ten (10) percent of the total contract price, computed on the basis of the proposal quantity and the contract unit price.) Should it become necessary, for the best interest of the owner, to make changes in excess of that herein specified, the same shall be covered by supplemental agreement.

The contractor shall not start work on any alteration requiring a supplemental agreement until the agreement setting forth the adjusted prices shall be executed by the owner and the contractor.

Should any of the changes, not requiring supplemental agreements, be made as provided herein, the contractor shall perform the work as altered, increased, or decreased at the contract unit price or prices.

In case a satisfactory adjustment in price cannot be reached for any item requiring a supplemental agreement, the owner reserves the right to terminate the contract as it applies to the items in question and make such arrangements as may be deemed necessary to complete the work.

40-04 OMITTED ITEMS. The engineer may, in writing, order omitted from the work any item other than major items found unnecessary to the project and such omission shall not be a waiver of any condition of the contract nor invalidate any of the provisions thereof. Major items may be omitted by supplemental agreements. The contractor will be paid for all work done toward the completion of the item prior to such omission as provided in Section 80-04.

40-05 EXTRA WORK—FORCE ACCOUNT. When work is necessary to the proper completion of the project for which no quantities or prices were given in the proposal or contract, the same shall be called extra work and shall be performed by the contractor when so directed in writing by the engineer. Extra work shall be performed by the contractor in accordance with these specifications in a proper and workmanlike manner and as may be directed by the engineer.

Prices for extra work shall be itemized and covered by a supplemental agreement submitted by the contractor and approved by the owner prior to the actual starting of such work. Should the parties be unable to agree on unit prices for the extra work or if this method is impractical, the engineer may instruct the contractor to proceed with the work by day labor or force account as hereinafter provided in Section 80-05.

Claims for extra work not authorized in writing by the engineer prior to the work being done will be rejected.

40-06 MAINTENANCE OF TRAFFIC. The contractor shall plan and prosecute his work, when the construction involves closing or relocation of any local road or highway, so that traffic will be hindered to a minimum. Unless otherwise stated in the plans or special provisions, through-traffic over local, State, or U. S. highways will be detoured away from the work under way and over marked detours or temporary roads to be maintained by others.

The contractor when engaged in construction projects on an existing operational field must plan and coordinate his work with the airport operational authorities in such a manner to insure safety and a minimum hindrance to flight operations.

40-07 REMOVAL AND DISPOSAL OF STRUCTURES AND OBSTRUCTIONS. All structures or obstructions found on the airport and shown on the plans which are not to remain in place or which are not to be used in the new construction shall be removed as directed by the engineer. Unless specified in the proposal, this work

will not be paid for separately but will be included in the price bid for clearing and grubbing. All material found on the airport or removed therefrom shall remain the property of the owner unless otherwise indicated.

40-08 USE OF MATERIALS FOUND ON THE WORK.

The contractor, with the approval of the engineer, may use in the construction of the airport any stone, sand, or gravel found in the excavation and will be paid for the removal of such material at the contract unit price for excavation, but he shall replace with other suitable material, without compensation, all of that portion of the material so removed and used as was contemplated for use in the embankments or otherwise. If it was intended that any or all of the material so excavated and used was to have been wasted, then the contractor will not be required to replace it.

The contractor shall not excavate any material from the airport which is not within the excavation as indicated by the slope and grade lines, without being authorized in writing by the engineer.

40-09 FINAL CLEANING UP. Upon completion of the work and before acceptance and final payment will be made, the contractor shall remove from the site all machinery, equipment, surplus, and discarded materials, rubbish, temporary structures, and stumps or portions of trees. He shall cut all brush and woods within the limits indicated and shall leave the site in a neat and presentable condition. Material, cleared from the site and deposited on property adjacent, will not be considered as having been disposed of satisfactorily.

SECTION 50

CONTROL OF WORK AND MATERIALS

50-01 AUTHORITY OF THE ENGINEER. The engineer shall decide any and all questions which may arise as to the quality and acceptability of materials furnished, work performed, and as to the manner of performance and rate of progress of said work. He shall decide all questions which may arise as to the interpretation of the specifications, or plans relating to the work, and the fulfillment of the contract on the part of the contractor, and all questions as to the rights of different contractors on the project. The engineer shall determine the amount and quality of the several kinds of work performed and materials furnished which are to be paid for under the contract.

50-02 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS. Finished surfaces in all cases shall conform to the lines, grades, cross-sections, and dimensions shown on the approved plans and working drawings. Any deviation from the approved plans and working drawings which may be required by the exigencies of construction will be determined by the engineer and authorized by him in writing.

50-03 COORDINATION OF SPECIFICATIONS, PLANS, AND SPECIAL PROVISIONS. These specifications, the plans, special provisions, and all supplementary plans and documents are essential parts of the contract, and a requirement occurring in one is just as binding as though occurring in all. They are intended to be cooperative to describe and provide for a complete work. In case of discrepancy, figured dimensions, unless obviously incorrect, shall govern over scaled dimensions. Plans shall govern over specifications and special provisions shall govern over both plans and specifications.

The contractor shall not take advantage of any apparent error or omission in the plans or specifications. In the event the contractor discovers any apparent error or discrepancy, he shall immediately call upon the engineer for his interpretation and decision, and such decision shall be final.

50-04 COOPERATION OF CONTRACTOR. The contractor will be supplied with two copies of the plans, specifications, and special provisions. He shall have available on the work at all times one copy each of said plans, specifications, and special provisions. Additional copies of plans, specifications, and special provisions can be obtained by the contractor for the cost of reproduction.

The contractor shall give to the work the constant attention necessary to facilitate the progress thereof and he shall cooperate with the engineer and his inspectors and with other contractors in every way possible. The engineer shall allocate the work and designate the sequence of construction in case of controversy between contractors. The contractor shall have a competent English-speaking superintendent on the work at all times who is fully authorized as his agent on the work, such superintendent shall be capable of reading and thoroughly understanding the plans and specifications and shall receive and fulfill instructions from the engineer, or his authorized representative.

The contractor shall furnish for use of the field engineers and inspectors an approved weatherproof building, when specified. This building shall be located conveniently near the construction and shall be separated from any building used by the contractor. The floor space shall be not less than ten (10) x twelve (12) feet, the ceiling not less than eight (8) feet in height, and there shall be at least three single-sash lighting windows. It shall be furnished with a wooden locker large enough for the storing of implements and testing equipment and with one bracketed wall table at least three (3) x six (6) feet in dimensions. The contractor shall furnish heat and light. No direct payment will be made for this building or any labor, material, ground rental, or other expense in connection therewith. The cost thereof shall be included in the price bid for the various items of the contract. The contractor and his superintendent shall provide all reasonable facilities to enable the engineer and inspector to inspect the workmanship and materials entering into the work.

50-05 CONSTRUCTION STAKES. The engineer will furnish the contractor with all lines, grades, and measurements necessary to the proper prosecution and control of the work contracted for under these specifications. The contractor shall satisfy himself as to the accuracy of all measurements before constructing any permanent structure and shall not take advantage of any errors which may have been made in laying out the work. Such stakes and markings as the engineer may set for either his own or the contractor's guidance shall be scrupulously preserved by the contractor. In case of negligence on the part of the contractor, or his employees, resulting in the destruction of such stakes or markings, an amount equal to the cost of replacing the same may be deducted from subsequent estimates due the contractor, at the discretion of the engineer.

50-06 APPROVAL OF SOURCES OF SUPPLY OF MATERIALS. The source of supply of each of the materials required may be approved by the engineer before delivery is started. Representative preliminary samples may be submitted by the contractor, producer, or owner of the supply for inspection or tests. The results obtained from testing such samples may be used for preliminary approval but will not be used as a final acceptance of the materials. All materials proposed to be used may be tested at any time during their preparation and use.

If, after trial, it is found that sources of supply which have been approved do not furnish a product of uniform quality, or if the product from any source proves unacceptable at any time, the contractor shall furnish approved material from another source.

50-07 APPROVAL AND ACCEPTANCE OF MATERIALS.

Samples of all materials for test upon which is to be based the acceptance or rejection, shall be taken by the engineer or his authorized representative at the discretion of the engineer. Materials may be sampled either prior to shipment or after being received at the place of construction. All sampling, inspection, and testing shall be done in accordance with the methods hereinafter prescribed.

The contractor shall provide such facilities as the engineer or his representative may require for conducting field tests and for collecting and forwarding samples. The contractor shall not use or incorporate into the work any materials represented by the samples until tests have been made and the material found to be acceptable. Only materials conforming to the requirements of these specifications and which have been approved by the engineer or his authorized agents shall be used in the work. Any material which, after approval, has for any reason become unfit for use shall not be incorporated into the work.

50-08 METHODS OF SAMPLING AND TESTING. Except as otherwise provided, sampling and testing of all materials, and the laboratory methods and testing equipment required under these specifications shall be in accordance with the 1947 edition of the "Standard Specifications for Highway Materials and Methods of Sampling and Testing" of A. A. S. H. O. Sampling and testing of materials not covered by A. A. S. H. O. specifications, and not otherwise provided for, shall be in accordance with the Standards and Tentative Methods of the A. S. T. M., published in 1946.

The testing of samples and materials shall be made at the expense of the owner. Laboratory sieves shall have square openings of the sizes specified. The contractor shall furnish the required samples without charge. The contractor shall give sufficient notification of the placing of orders for materials to permit testing.

50-09 STORAGE. Materials shall be stored so as to insure the preservation of their quality and fitness for the work. When considered necessary they shall be placed on wooden platforms, or other hard, clean surfaces and not on the ground, and shall be placed under cover when directed. Stored materials shall be located so as to facilitate prompt inspection.

50-10 AUTHORITY AND DUTIES OF INSPECTORS. Inspectors, employed by the owner, shall be authorized to inspect all work done and all material furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. The inspector is not authorized to revoke, alter, or waive any requirements of the specifications. He is authorized to call the attention of the contractor to any failure of the work or materials to conform to the specifications and contract. He

shall have the authority to reject materials or suspend the work until any questions at issue can be referred to and decided by the engineer.

The inspector shall in no case act as foreman or perform other duties for the contractor, nor interfere with the management of the work by the latter. Any advice which the inspector may give the contractor shall in nowise be construed as binding to the engineer in any way, or releasing the contractor from fulfilling all of the terms of the contract.

If the contractor refuses to suspend operations on verbal order, the inspector shall issue a written order giving the reason for shutting down the work. After placing the order in the hands of the man in charge, the inspector shall immediately leave the job. Work done during the absence of the inspector will not be accepted nor paid for.

50-11 INSPECTION. The contractor shall furnish the engineer with every reasonable facility for ascertaining whether or not the work, as performed, is in accordance with the requirements and intent of the specifications and contract. If the engineer requests it, the contractor at any time before acceptance of the work shall remove or uncover such portions of the finished work as may be directed. After examination, the contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, will be paid for as extra work, but should the work so exposed or examined prove unacceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed, shall be at the contractor's expense. Any work done or materials used without suitable supervision or inspection by the engineer or his authorized representative may be ordered removed and replaced at the contractor's expense.

50-12 REMOVAL OF DEFECTIVE AND UNAUTHORIZED WORK. All work which has been rejected or condemned shall be repaired, or if it cannot be satisfactorily repaired, be removed and replaced at the contractor's expense. Materials not conforming to the requirements of the specifications shall be removed immediately from the site of the work, and replaced with satisfactory material by the contractor at his expense.

Work done without lines and grades having been given, work done beyond the lines and grades shown on the plans, or as given, except as herein provided, work done without proper inspection, or any extra or unclassified work done without written authority and prior agreement in writing as to prices, will be done at the contractor's risk and will be considered unauthorized and, at the option of the engineer, may not be measured and paid for and may be ordered removed and replaced at the contractor's expense.

Upon the failure of the contractor to repair satisfactorily or to remove and replace, if so directed, rejected, unauthorized, or condemned work or materials immediately after receiving formal notice

from the engineer, the owner may recover for such defective work or materials on the contractor's bond or by action in a court having proper jurisdiction over such matters, or may employ labor and equipment and satisfactorily repair or remove and replace such work and charge the cost of the same to the contractor, which cost will be deducted from any money due him.

50-13 DISPUTED CLAIMS FOR EXTRA WORK. In case the contractor deems extra compensation is due him for work or materials not clearly covered in the contract, or not ordered by the engineer as an extra, the contractor shall notify the engineer in writing of his intention to make claim for such extra compensation before he begins the work on which he bases the claim and shall afford the engineer every facility for keeping actual cost of the work. Failure on the part of the contractor to give such notification or to afford the engineer proper facilities for keeping strict account of actual cost shall constitute a waiver of the claim for such extra compensation. The filing of such notice by the contractor and the keeping of costs by the engineer shall not in any way be construed to prove the validity of the claim. When the work has been completed, the contractor shall within ten (10) days file his claim for extra compensation with the engineer, who will present it to the owner for consideration.

SECTION 60

LEGAL RELATIONS AND RESPONSIBILITIES TO PUBLIC

60-01 LAWS TO BE OBSERVED. The bidder is assumed to be familiar with all Federal, State, Territory, or possession, and local laws, codes, ordinances, and regulations which, in any manner, affect those engaged or employed in the work or the material or equipment used in or upon the site, or in any way affect the conduct of the work. No pleas of misunderstanding or ignorance on the part of the contractor will, in any way, serve to modify the provisions of the contract.

The contractor, at all times, shall observe and comply with all Federal, State, Territory, or possession, and local laws, codes, ordinances, and regulations in any manner affecting the conduct of the work, and the contractor and his surety shall indemnify and save harmless the owner and all his officers, agents, and servants against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order, or decree, whether by himself or his employees.

60-02 PERMITS AND LICENSES. The contractor shall procure all permits and licenses, pay all charges and fees, and give all notices necessary and incidental to the due and lawful prosecution of the work.

60-03 PATENTED DEVICES, MATERIALS AND PROCESSES. If the contractor is required or desires to use any design, device, material, or process covered by letters patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or patent owner. The contractor and the surety shall indemnify and save harmless the owner from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright in connection with the work agreed to be performed under this contract, and shall indemnify the owner for any costs, expense, and damages which it may be obliged to pay for reason of any such infringement at any time during the prosecution, or after the completion of the work.

60-04 FEDERAL PARTICIPATION. The attention of the contractor is invited to the fact that pursuant to the provisions of the Act of Congress known as the Federal Airport Act, approved May 13, 1946, with subsequent amendments, the United States Government may pay a portion of the cost of this improvement. The above Act of Congress provides that the construction work and labor in each State shall

be done in accordance with the laws of the State subject to the inspection and approval of the CAA and in accordance with the rules and regulations made pursuant to said act. The construction work, therefore, will be subject to such inspection by the Civil Aeronautics Administrator or his agents as may be deemed necessary to meet with above requirements when Federal funds are used, but such inspection will in no sense make the Federal Government a party to this contract and will in no way interfere with the rights of either party hereunder.

60-05 SANITARY PROVISIONS. The contractor shall provide and maintain in a neat and sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements and regulations of the State, Territory, or local Department of Health, or of other agencies having jurisdiction therewith.

60-06 PUBLIC CONVENIENCE AND SAFETY. Materials stored upon the airport shall be so placed and the work shall, at all times, be so conducted as to cause no greater obstruction to the air and ground traffic than is considered necessary by the engineer. No runway, taxiway or roadway shall be closed or opened except by express permission by the engineer.

Where the contractor is required to construct temporary crossing for streams, culverts, ditches, or trenches his responsibility for accidents shall include the approaches as well as the structures of such crossings.

60-07 BARRICADES AND WARNING SIGNS. The contractor shall, before closing or in any way tearing up an existing runway, taxiway, or roadway furnish and erect approved signs and lights to protect the traffic and the work. The signs warning air traffic shall be placed on the field at such locations that they may be seen from the air. They shall be painted so as to be visible. The paint shall be renewed as often as necessary to keep the signs thoroughly covered. "Do Not Land" signs shall be erected on projects closed to air traffic. From sunset to sunrise the contractor shall furnish and maintain red lights and/or flares.

The contractor shall furnish watchmen in sufficient numbers to protect any new work. Failure to comply with this requirement will result in the engineer shutting down the work until the contractor shall have provided the necessary protection.

The contractor shall at his own expense repair all damage done the work before it is opened for traffic and shall be responsible for the prosecution of the offender under the provision of the State laws.

60-08 USE OF EXPLOSIVES. When the use of explosives is necessary for the prosecution of the work, the contractor shall use the utmost care so as not to endanger life or property, and whenever directed, the number and size of the charges shall be reduced. The contractor shall notify the proper representatives of any public service corporation, any company, or any individual at least eight (8) hours in advance of any blasting which may damage his or their property on, along, or adjacent to the airport.

All explosives shall be stored in a secure manner and all storage places shall be marked clearly "DANGEROUS EXPLOSIVES", and shall be in care of competent watchmen at all times.

60-09 PROTECTION AND RESTORATION OF PROPERTY. The contractor shall not enter upon private property for any purpose without first obtaining permission, and he shall be responsible for the preservation of all public and private property, trees, fences, monuments, underground structures, etc., on and adjacent to the airport, and shall use every precaution necessary to prevent damage or injury thereto.

He shall use suitable precautions to prevent damage to any public or private property, and he shall protect carefully, from disturbance or damage, all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location, and shall not remove them until directed.

He shall be responsible for all damage or injury to property of any character resulting from any act, omission, neglect or misconduct in his manner, or method of executing said work, or due to his non-execution of said work, or at any time due to defective work or materials, and said responsibility shall not be released until the work shall have been completed and accepted.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the nonexecution thereof on the part of the contractor, he shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done by repairing, rebuilding, or otherwise restoring, as may be directed, or he shall make good such damage or injury in an acceptable manner.

60-10 RESPONSIBILITY FOR DAMAGE CLAIMS. The contractor and his surety shall indemnify and save harmless the owner and all his officers, agents, and employees from all suits, actions, or claims of any character, name and description brought for or on account of any injuries or damages received or sustained by any person, persons, or property, by or from the said contractor or his employees or by or in consequence of any neglect in safeguarding the work, or through the use of unacceptable materials in constructing the work or by or on account of any act or omission, neglect, or misconduct of the said contractor or by or on account of any claims or amounts recovered by any infringement of patent, trademark, or copyright, or from any claims or amounts arising or recovered under the "Workman's Compensation Law," or any other law, ordinance, order or decree, and so much of the money due the said contractor under and by virtue of his contract, as shall be considered necessary by the owner, may be retained or, in case no money is due, his surety shall be held until such suit or suits, action or actions, claim or claims for injuries or damages as aforesaid shall have been settled and satisfactory evidence to that effect furnished to the owner.

60-11 OPENING OF SECTION OF AIRPORT TO TRAFFIC. Whenever, in the opinion of the engineer, any runway, or any structure, is in acceptable condition, it may be opened to traffic upon the written order of the engineer. The opening of any runway shall be held as an acceptance of said runway, but shall not be considered as a waiver of any of the provisions of these specifications or contract. Pending final completion and acceptance of the work all necessary repairs and renewals on any section of the runway, so opened, due to defective material or work, to natural causes other than ordinary wear and tear, or to the operations of the contractor, shall be performed by and at the expense of the contractor.

60-12 CONTRACTOR'S RESPONSIBILITY FOR WORK. Until acceptance by the engineer of any part or all of the construction, as provided for in these specifications, it shall be under the charge and care of the contractor, and he shall take every necessary precaution against injury or damage to any part of the work by the action of the elements or from any other cause whatsoever, whether arising from the execution or from the nonexecution of the work. The contractor shall rebuild, repair, restore, and make good, at his own expense, all injuries or damage to any portion of the work occasioned by any of the above causes before its completion and acceptance.

60-13 PERSONAL LIABILITY OF PUBLIC OFFICIALS. In carrying out any of the above provisions or in exercising any power or authority granted to him by this contract, there shall be no liability upon said engineer or his authorized assistants, either personally or as an official of the owner, it being understood that in such matters he acts as an agent and representative of the owner.

60-14 NO WAIVER OF LEGAL RIGHTS. Inspection by the engineer or by any of his duly authorized representatives, any order, measurement, or certificate by the engineer; any order by the owner for the payment of money, any payment for or acceptance of any work or any extension of time; or any possession taken by the owner shall not operate as a waiver of any provision of the contract, or any power therein preserved to the owner, or of any right to damages therein provided. Any waiver of any breach of the contract shall not be held to be a waiver of any other or subsequent breach.

The owner reserves the right to correct any error that may be discovered in any estimate that may have been paid, and to adjust the same to meet the requirements of the contract and specifications. The owner reserves the right to claim and recover, by process of law, sums as may be sufficient to correct any error or make good any deficit in the work resulting from such error, dishonesty, or collusion upon conclusive proof of collusion or dishonesty between the contractor or his agents and the engineer or his assistants discovered in the work after the final payment has been made.

60-15 RIGHT-OF-WAY. The owner will secure all necessary right-of-way for construction.

SECTION 70

PROSECUTION AND PROGRESS

70-01 SUBLETTING OR ASSIGNING OF CONTRACT.

The owner will not recognize any subcontractor on the work. The contractor shall at all times when work is in operation be represented either in person, by a qualified superintendent, or other designated representative.

Should the contractor elect to assign his contract, the said assignment shall be concurred in by the surety, shall be presented for the consideration and approval of the owner and shall be consummated only on the written approval. In case of approval, the contractor shall file with the engineer copies of all subcontracts.

70-02 PROSECUTION OF WORK. The contractor shall begin the work to be performed under the contract within ten (10) days of the date set by the engineer in the written notice to proceed. The contractor shall notify the engineer at least twenty-four (24) hours in advance of the time he intends to start. The contractor shall operate at such points as the engineer may direct. The contractor shall conduct the work in such a manner and with sufficient materials, equipment, and labor as is considered necessary to insure its completion within the time limit set forth in the proposal. Should the prosecution of work for any reason be discontinued by the contractor, with the consent of the engineer, he shall notify the engineer at least twenty-four (24) hours in advance of resuming operations.

70-03 LIMITATION OF OPERATION. On grading work the drainage structures when designated shall be completed a sufficient time in advance of the grading. Each item of work shall be prosecuted to completion without delay and in no instance will the contractor be permitted to transfer his forces from uncompleted work to new work without the permission of the engineer. The contractor may be required to submit a schedule of operations for approval. The contractor shall not open up work to the prejudice of work already started.

70-04 CHARACTER OF WORKMEN AND EQUIPMENT. The contractor shall employ such superintendents, foremen, and workmen as are careful and competent, and the engineer may demand the dismissal of any person or persons employed by the contractor in, about, or upon the work who shall misconduct himself or be incompetent or negligent in the proper performance of his or their duties, or neglects or refuses to comply with the directions given, and such person or

persons shall not be employed again thereon without the written consent of the engineer. Should the contractor continue to employ, or again employ such person or persons, the engineer may withhold all estimates, which are or may become due, or the engineer may suspend the work until such orders are complied with.

All workmen must have sufficient skill and experience to properly perform the work assigned them. All workmen engaged on special work or skilled work, such as bituminous courses or mixtures, concrete pavements or structures, electrical installation, turfing and planting, or in any trade, shall have sufficient experience in such work to properly and satisfactorily perform it and operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in these specifications. Otherwise the engineer may take action as above prescribed.

In the employment of labor, preference shall be given, other conditions being equal, first to veterans as ordered in Public Law 377, 79th Congress, Section 14, and second to bona fide residents of the county wherein the work is being done, but no other preference or discrimination among citizens of the United States shall be made, except as may be required by special labor provisions.

The contractor shall furnish such equipment as is considered necessary for the prosecution of the work in an acceptable manner and at a satisfactory rate of progress. All equipment, tools, and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer and shall be maintained in a satisfactory working condition. Equipment used on any portion of the work shall be such that no injury to the work, runways, adjacent property, or other objects will result from its use. The contract may be annulled if the contractor fails to provide adequate equipment for the work.

No convict labor shall be employed.

70-05 TEMPORARY SUSPENSION OF WORK. The engineer shall have the authority to suspend the work wholly, or in part, for such period or periods as he may deem necessary, due to unsuitable weather, or such other conditions as are considered unfavorable for the suitable prosecution of the work, or for such time as is necessary, due to the failure on the part of the contractor to carry out orders given or perform any or all provisions of the contract.

If it should become necessary to stop work for an indefinite period, the contractor shall store all materials in such manner that they will not become an obstruction, nor become damaged in any way, and he shall take every precaution to prevent damage or deterioration of the work performed; provide suitable drainage by opening ditches, shoulder drains, etc., and erect temporary structures where necessary.

The contractor shall not suspend the work without written authority from the engineer, and shall proceed with the work promptly when notified by the engineer to resume operations.

70-06 DETERMINATION AND EXTENSION OF CONTRACT TIME FOR COMPLETION. The contractor shall perform fully, entirely, and in a satisfactory and acceptable manner the work contracted, within the number of working days stipulated in the proposal and the contract. Time will be assessed against the contractor beginning with the actual date the work is started when this is in accordance with the notice to proceed.

If the contractor does not begin the work within the limit as designated in the notice to proceed, the working days shall start on the first working day after the expiration of the ten (10) day limit as stated in the notice to proceed. No time will be charged for days on which the contractor is unable to proceed with work, on the major item under construction at that stage of the work, for at least six (6) hours with the normal force employed on the major items under construction. In adjusting the contract time for the completion of the project, all strikes, lock-outs, unusual delays in transportation, or any condition over which the contractor has no control, and also any suspensions ordered by the engineer for causes not the fault of the contractor, shall be excluded from the computation of the contract time for completion of the work. If the satisfactory execution and completion of the contract shall require work or materials in greater amounts or quantities than those set forth in the contract, then the contract time shall automatically be increased in the same proportion as the cost of the additional work bears to the original work contracted for. No allowances will be made for delays or suspensions of the prosecution of the work due to the fault of the contractor.

The engineer will prepare for each estimate a statement of the working days charged during the period, the working days allowed in the contract, and the working days remaining under the contract. Copies of such statement will be promptly submitted to the contractor for his approval and signature. The contractor shall sign the statement or submit his objection within five days, specifying the days he shall be allowed, or the engineer's statement will be accepted as correct.

70-07 FAILURE TO COMPLETE WORK. For each working day that any part of the work remains uncompleted after the expiration of the time allowed for completion of the work stipulated in the contract or as automatically increased by the additional work or materials ordered after the contract is signed, the sum per day given in the following schedule shall be deducted from any moneys due the contractor, or if no money is due the contractor, the owner shall have the right to recover said sum or sums from the contractor, from the surety, or from both. The amount of these deductions are to cover liquidated damages to the owner incurred by additional and other expenses due to the failure of the contractor to complete the work or any part of the work within the time specified, and such deductions are not to be considered as penalties.

<i>Amount of Contract</i>	<i>Amount of Liquidated Damages per Day</i>
Less than \$5,000-----	\$10.00
\$5,000 and less than \$15,000-----	15.00
\$15,000 and less than \$50,000-----	20.00
\$50,000 and less than \$100,000-----	30.00
\$100,000 and less than \$500,000-----	50.00
\$500,000 and less than \$1,000,000-----	75.00
Over \$1,000,000-----	100.00

The damages stipulated above are to be deducted from any moneys due the contractor as liquidated damages for the loss to the owner on account of the expense due to the employment of engineers and their assistants and to any other expenses after the expiration of completion time set forth by the engineer.

70-08 ADJUSTMENT FOR SUSPENDED WORK. In the event the contractor is ordered by the engineer, in writing, to suspend work for some unforeseen cause not provided for in the specifications, special provisions, proposal, contract, or work order and over which the contractor has no control, the contractor may be reimbursed for actual money expended on the job during the period of shut down. No allowance will be made for anticipated profits. The period of shut down shall be computed from the date set out in written order for work to cease until the date of the order for work to resume. Claims for such compensation shall be filed with the owner within ten (10) days after date of order to resume work or such claims will not be considered. The contractor shall submit with his claim, substantiating papers covering the entire amount shown on the claim. The owner shall take the claim under consideration, and may make such investigations as are deemed necessary, and shall be the sole judge as to the equitability of such claim and such decision shall be final. No provision of this article shall be construed as entitling the contractor to compensation for delays due to inclement weather, delays due to failure for surety, for suspensions made at the request of the contractor, or for any other delay provided for in the specifications, special provisions, proposal, contract, or work order.

70-90 ANNULMENT OF CONTRACT. The contract, of which these specifications form a part, may be annulled by the owner for the following reasons:

- (a) Failure of the contractor to start the work on the date given in the notice to proceed.
- (b) Substantial evidence that the progress being made by the contractor is insufficient to complete the work within the specified time.
- (c) Deliberate failure on the part of the contractor to observe any requirement of these specifications.

(d) Failure of the contractor promptly to make good any defects in materials or work or any defects of any other nature, the correction of which has been directed in writing by the engineer.

(e) Substantial evidence of collusion for the purpose of illegally procuring a contract or perpetrating fraud on the owner in the construction of work under contract.

Before the contract is annulled, the contractor and his surety will first be notified in writing by the engineer of the conditions which make annulment of the contract imminent. Ten (10) days after this is given, if a satisfactory effort has not been made by the contractor or his surety to correct the conditions, the owner may declare the contract annulled and notify the contractor and his surety accordingly.

Upon receipt of notice from the owner that the contract has been annulled the contractor shall immediately discontinue all operations. The engineer may then proceed with the work in any lawful manner that he may elect until it is finally completed.

The right is reserved to take possession of any machinery, implements, tools, or materials of any description that shall be found upon the work, to account for said equipment and materials, and to use the same to complete the project. When the work is thus finally completed the total cost of the same will be computed. If the total cost is more than the contract price, the difference shall be made up either by the contractor or his surety. If the total cost is less than the contract price, the difference will be paid to the contractor or his surety. In case of annulment all expenses incident to ascertaining and collecting losses under the bond, including engineering and legal services, shall be assessed against the bond.

70-10 PROCEDURE FOR COMPLETION OF SEASONAL WORK. The following procedure will be followed to insure the fair and satisfactory completion of turfing and planting items requiring specific seasonal or climatic conditions for starting and involving various lengths of time for completion over which the contractor and owner have no control. This period of time will be limited as follows: not less than two (2) months nor more than twelve (12) months from the time of satisfactory completion and acceptance of all other items of the contract.

An amount equivalent to ten (10) percent of moneys due for work completed and accepted will be withheld under provisions of paragraph 80-06 (Partial Payments). From this ten (10) percent withheld will be deducted a sum equal to fifty (50) percent of the total bid prices of the uncompleted turfing, planting, and similar items. If the ten (10) percent withheld is not equal to the fifty (50) percent of the turfing and planting items, the total ten (10) percent will be retained. If the ten (10) percent withheld is more than the fifty (50) percent of the turfing and planting items, the balance will be paid to the contractor when satisfactory clearance has been submitted to the owner.

As the turfing and planting work progresses, a ten (10) percent deduction shall be withheld from the estimates under provisions of paragraph 80-06. When the turfing and plant work is fifty (50) percent or more completed, the amount of money withheld according to the previous paragraph will be paid the contractor.

In event the contractor fails to start work on the uncompleted items of turfing and planting within the period designated by the special provisions, specifications, or as established by the engineer, the money withheld, according to the second paragraph of section 70-10, will be considered liquidated damages.

In event the contractor cannot start the work within twelve (12) months as described in paragraph one of section 70-10, through no fault of his own, he shall be paid all deductions withheld on such work.

70-11 FULFILLMENT OF CONTRACT. The contract will be considered fulfilled when all the work has been completed, the final inspection and acceptance has been made by the engineer. The contractor will then be released from further obligation except as may be required by law and by his surety.

SECTION 80

MEASUREMENT AND PAYMENT

80-01 MEASUREMENT OF QUANTITIES. The determination of quantities of work acceptably completed under the terms of the contract, or as directed by the engineer in writing, will be made by the engineer and based on measurements taken by him or his assistants. These measurements will be taken according to the United States standard measure. All surface and linear measurements will be taken horizontally unless otherwise shown on plans or specified. Structures shall be measured to the neat lines as shown on the plans, or as ordered in writing by the engineer.

When base course, topsoil, surface course, or any materials are measured by the cubic yard in the vehicle, such measurement shall be taken at the point of delivery. The capacity of all vehicles shall be plainly marked on said vehicle and the capacity or marking shall not be changed without permission of the engineer. The engineer may require all vehicles to have uniform capacity.

80-02 SCOPE OF PAYMENT. The contractor shall accept the compensation, as herein provided, in full payment for furnishing all materials, equipment, labor, tools, and incidentals necessary to complete the work and for performing all work contemplated and embraced under the contract; also for loss or damage arising from the nature of the work, or from the action of the elements, or from any unforeseen difficulties which may be encountered during the prosecution of the work until the final acceptance by the engineer, and for all risks of every description connected with the prosecution of the work, for all expenses incurred in consequence of the suspension or discontinuance of the work as herein specified, and for any infringement of patent, trade-mark, or copyright; and for completing the work according to the plans and specifications. Neither the payment of any estimate nor of any retained percentage shall relieve the contractor of any obligation to make good any defective work or material.

No moneys, payable under contract, or any part thereof, except the estimate for the first month or period, shall become due and payable if the owner so elects, until the contractor shall satisfy the said owner that he has fully settled or paid for all materials and equipment used in or upon the work and labor done in connection therewith, and the owner, if he so elects, may pay any or all such bills, wholly or in part, and deduct the amount or amounts so paid from any monthly or final estimate, excepting the first estimate.

In the event the surety on any contract or payment bond given by the contractor becomes insolvent, or is placed in the hands of a receiver, or has its right to do business in a State revoked as provided by law, the owner may, at its election, withhold payment of any estimate filed or approved by the engineer until the contractor shall give a good and sufficient bond in lieu of the bond so executed by such surety.

80-03 PAYMENT FOR INCREASED OR DECREASED QUANTITIES. When alterations in the plans or quantities of work not requiring supplemental agreements, as hereinbefore provided for, are ordered and performed, the contractor shall accept payment in full at the contract price for the actual quantities of work done. No allowance will be made for anticipated profits. Increased or decreased work involving supplemental agreements will be paid for as stipulated in such agreements.

80-04 PAYMENT FOR OMITTED ITEMS. As provided in paragraph 40-04, the engineer shall have the right to cancel or alter the portions of the contract relating to the construction of any item or items therein by the payment to the contractor of a fair and equitable amount covering all items of costs incurred prior to the date of cancellation, alteration, or suspension of the work by order of the engineer. The contractor shall accept payment in full at the contract unit prices for any work actually performed prior to the date of cancellation, alteration, or suspension of the work by order of the engineer. No allowance will be made for anticipated profits in reimbursements to the contractor for omitted items of work. Acceptable materials ordered by the contractor or delivered on the work prior to the date of cancellation, alteration, or suspension of the work by order of the engineer will be paid for at the actual cost to the contractor and shall thereupon become the property of the owner. The contractor shall submit immediately certified statements covering all money expended in preparation for any omitted item and he shall be reimbursed for any money expended in preparation for work on any omitted item when such preparation has no value to the remaining items of the contract, or for a proportionate amount based on the total contract price over which such preparation would ordinarily be distributed when other items are included in such preparation.

80-05 PAYMENT FOR EXTRA AND FORCE ACCOUNT WORK. All extra work done on a force account basis will be paid for in the manner hereinafter described, and the compensation thus provided shall be accepted by the contractor as payment in full for the use of small tools, superintendent's services, timekeeper's service, premium on bond, and all other overhead expenses incurred in the prosecution of all extra work done on a force account basis. Payment will be made as follows:

(a) For all materials purchased by the contractor and used in this specific work he will receive the actual cost of such materials including freight charges, as shown by original receipted bills for materials and

freight, to which will be added an amount equal to fifteen (15) percent of the sum thereof.

(b) For all labor, teams, and foremen, engaged in the specific operation, the contractor will receive the wage prevailing and paid on the project for each and every hour that said labor, teams, and foremen are actually engaged in such work, to which will be added an amount equal to fifteen (15) percent of the sum thereof. In addition, the contractor shall be paid a sum equal to the workman's compensation insurance premium and the actual cost of Social Security taxes, computed on the base rate for the class of work involved, for the actual amount of the payroll.

(c) For any machine, power, and equipment which it may be deemed necessary or desirable to use, the contractor will be allowed a reasonable rental price, which will be agreed upon in writing before such work is begun for each and every hour that said machinery or equipment is in use on such work, to which sum no percentage will be added.

The contractor's timekeeper and the inspector shall compare records of extra work on a force account basis at the end of each day. Copies of these records shall be made in duplicate by the inspector and shall be signed by both the inspector and the contractor's timekeeper, one copy being forwarded respectively to the engineer and the contractor.

No extra work will be paid for unless unit prices or wages have been agreed upon in writing before such work is started.

Bills for force account work must be sworn to and submitted in triplicate to the engineer with the current monthly estimate.

80-06 PARTIAL PAYMENTS. The engineer will make written estimates of the materials complete in place and the amount of work performed in accordance with the contract during the current period of time between estimates and the value thereof figured at the contract unit prices. From the total of the estimate so ascertained will be deducted an amount equivalent to ten (10) percent of the whole, to be retained by the owner until after the completion of the entire contract in an acceptable manner, and the balance of the sum equivalent to ninety (90) percent of the whole, shall be certified to by the engineer for payment. Estimates will be made monthly or for such longer periods as mutually agreed upon. No estimates except final estimates will be made for a sum less than five hundred dollars (\$500.00). The estimates will be approximate only and all partial or monthly estimates and payments shall be subject to correction in the estimate rendered following discovery of an error in any previous estimates.

Should any defective work or material be discovered, or should a reasonable doubt arise as to the integrity of any part of the work completed previous to the final acceptance and payment, there will be deducted from the first estimate rendered after the discovery of such work an amount equal in value to the defective or questioned work,

and this work will not be included in a subsequent estimate until the defects have been remedied or the causes for doubt removed.

80-07 ACCEPTANCE AND FINAL PAYMENT. Within ten (10) days after the completion of any contract and before final acceptance, a final inspection must be made by the engineer to determine whether the work has been completed in accordance with the contract, plans, and specifications. All prior partial estimates and payments shall be subject to correction in the final estimate and payment. When the work has been so completed and certified to the owner, the work will be considered accepted and the final estimate shall be executed and submitted.

PAVING MATERIAL DETAILS

Only approved materials conforming to the requirements of the specifications shall be used in the work. All materials may be subjected to inspection and tests at any time during the progress of their preparation or use. The source of supply of each of the materials shall be approved by the engineer before delivery or use is started. Representative laboratory samples of the materials shall be submitted by the contractor when required for examination and test. Materials shall be stored and handled so as to insure the preservation of their quality and fitness for use, and shall be so located as to facilitate prompt shipment. All equipment for handling and transporting materials and mixtures must be clean before any material or mixture

- (1) Two gradations, No. 4 to 1 inch and 1 inch to 2 inches, per
- (2) Two gradations, No. 4 to $\frac{1}{2}$ inch and $\frac{1}{2}$ inch to 1 $\frac{1}{2}$ inches.

DIVISION II—CONSTRUCTION MATERIALS

SECTION 90

90 SCOPE. This division will not contain complete construction material requirements for the types of airport work included in this book, but will be complementary to the regular construction specifications. It is intended that this section will provide a quick, convenient reference for the more common and most used materials. For the most part, the requirements included here will be those that can be referenced to standards already accepted and published. Under each material listed, there will be shown the items of construction in which the particular material will or may be used. The regular construction specifications will include the requirements for all materials needed for the completed item. This is accomplished either by reference to acceptable standards or by indicating full details.

PAVING MATERIAL DETAILS

90-01 GENERAL. The materials included under this heading are those needed for paving, fencing, and drainage items. The specifications cover the quality and size requirements of materials intended for the construction of airports. The requirements are not merely descriptions of materials but provide means for determining whether such materials or articles conform to the details prescribed and considered necessary for satisfactory construction. The material list and references presented here are condensed and brief. All of the requirements of all materials needed for the completed construction will be included in the appropriate item specification. If sufficient details are not given in this division, then the regular construction specifications should be investigated for complete information.

Only approved materials conforming to the requirements of the specifications shall be used in the work. All materials may be subjected to inspection and tests at any time during the progress of their preparation or use. The source of supply of each of the materials shall be approved by the engineer before delivery or use is started. Representative preliminary samples of the materials shall be submitted by the contractor, when required, for examination and test. Materials shall be stored and handled so as to insure the preservation of their quality and fitness for use, and shall be so located as to facilitate prompt inspection. All equipment for handling and transporting materials and mixtures must be clean before any material or mixtures

are placed therein. The testing and sampling shall be done in accordance with the 1947 publication of the Specifications of the A. A. S. H. O., or in accordance with the 1946 publication of the A. S. T. M., or with other Standard Specifications and Testing Methods as referred to in the appropriate specification for each construction item. The compaction-control tests and sand-bearing tests referred to in the different items are given in this book under Appendix A.

90-02 PORTLAND CEMENT. The cement used shall be a standard brand of Portland cement, a standard brand of high early strength Portland cement, or a standard brand of moderate sulphate-resisting cement. Portland cement shall conform to the standard specifications of A. S. T. M. Designation C-150. Air-entrained cement shall conform to the Specifications of A. S. T. M. Designation C-175.

Cement will be used in:

Items P-301, P-302, P-501, and P-610.

90-03 NATURAL CEMENT. Natural cement shall conform to the requirements of A. S. T. M. Designation C-10 except that the use of a grinding aid will be mandatory. The natural cement shall be made water repellant by the use of a grinding aid composed of 0.1 and 0.2 percent paraffin in a carrier of oil or petroleum distillate not to exceed 0.8 percent by weight. In lieu thereof, the manufacturer may use from 0.1 to 0.2 percent tallow or fatty acid. A material known commercially as Darex AEA may be used in natural cement in amounts from 0.1 to 0.35 percent. Other grinding aids or air-entrainment agents may be used upon approval of the engineer.

Natural cement may be used in:

Items P-501 and P-610.

90-04 FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE. The fine aggregate for concrete pavement and structures shall conform to the A. A. S. H. O. Specification M-6. The total amount of deleterious substances such as coal, clay lumps, shale, mica, coated grains, and soft fragments shall not exceed five (5) percent. The total loss when the fine aggregate is subjected to five cycles of the sodium sulphate soundness test shall not be greater than ten (10) percent by weight.

Fine aggregate will be used in:

Items P-501 and P-610.

90-05 COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE. The coarse aggregate for concrete pavement shall conform to the A. A. S. H. O. Specification M-80. The percentage of wear, Los Angeles Rattler Test, shall not be more than 50. The total amount of shale, coal, clay lumps, and soft fragments shall not exceed five (5) percent. The gradation of the coarse aggregate shall be either:

- (1) Two gradations, No. 4 to 1 inch and 1 inch to 2 inches, or
- (2) Two gradations, No. 4 to $\frac{3}{4}$ inch and $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches.

The coarse aggregate for concrete structures shall meet the above requirements but shall have one of the following gradations:

- (a) No. 4 to $\frac{3}{4}$ inch.
- (b) No. 4 to 1 inch.
- (c) No. 4 to $1\frac{1}{2}$ inches.

Coarse aggregate will be used in:

Items P-501 and P-610.

90-06 WATER FOR CONCRETE. The water used in concrete shall be clean, clear, and free from injurious amounts of sewage, oil, acid, strong alkalis or vegetable matter, and also shall be free from clay and loam. If the water is of questionable quality, it shall be tested in accordance with A. A. S. H. O. Method T-26.

Water will be used in:

Items P-301, P-302, P-501, and P-610.

90-07 STEEL REINFORCEMENT. (a) *Concrete Pavement.* Reinforcing may consist of either welded wire fabric or bar mats. Welded wire fabric shall meet the requirements of A. A. S. H. O. Specification M-55. Bar mats shall meet the requirements of A. A. S. H. O. Specification M-54, with the following requirements:

(1) All bar shall be intermediate grade billet steel, meeting A. A. S. H. O. Specification M-31.

(2) Longitudinal and transverse bars shall be connected at all marginal intersections and at least every alternate interior intersection, either by welding or by means of approved clips.

(3) If mats are fabricated by welding, plain bars may be used; if fabricated by means of clips, bars larger than $\frac{1}{4}$ -inch diameter shall be deformed bars.

(4) All bars shall be full weight called for according to size.

(b) *Concrete Structures.* Concrete reinforcement bars shall meet the requirements of A. A. S. H. O. Specification M-31. Welded wire fabric for concrete reinforcement shall conform to the requirements of A. A. S. H. O. Specification M-55. Reinforcing bars shall be of the grade and plain or deformed as indicated on the plans or as called for in the proposal. All bars shall be the full weight called for according to size.

Steel reinforcement may be used in:

Items P-501 and P-610.

90-08 DOWEL AND TIE BARS. Dowel and tie bars shall conform to the following requirements:

- (a) Billet steel shall conform to A. A. S. H. O. Specification M-31.
- (b) Rail steel shall conform to A. A. S. H. O. Specification M-42.
- (c) Axle steel shall conform to A. A. S. H. O. Specification M-53.
- (d) Dowel and tie bars shall be of the size, type, and number shown on the plans and shall be installed in such manner and location as are indicated.

The bars shall be free from flattening or burring of ends. If necessary, the ends of the bars shall be ground to remove the burrs resulting from shearing.

Dowel and tie bars will be used in:

Items P-501 and P-610.

90-09 PREMOULDED JOINT FILLER. Premoulded joint material for expansion joints shall meet the requirements of one of the following A. A. S. H. O. Specifications: M-58, M-59, or M-90.

Premoulded joint filler will be used in:

Items P-501 and P-610.

90-10 JOINT FILLER. The filler for joints in concrete shall meet the requirements of Item P-605 or shall be an asphalt filler meeting the requirements of A. A. S. H. O. Specification M-20 with 50-60 penetration used in the southern States and 85-100 penetration used in the northern States. Where tar is available, it may be used and shall meet the requirements of A. A. S. H. O. Specification M-52. It shall be a heavy grade similar to RT-12.

Joint filler will be used in:

Items P-501 and P-610.

90-11 ASPHALT CEMENT. Asphalt cement for hot central plant mix shall meet the requirements of A. A. S. H. O. Specification M-20 or Specification M-22. The penetration of petroleum asphalt shall be between 100 and 150. The penetration of native asphalt shall be between 85 and 150. A limited range or grade shall be selected for each project such as 85-100; 100-120; or 120-150. The penetration grade shall be indicated in the proposal, shown on the plans or as directed by the engineer.

Asphalt cement may be used in:

Items P-201, P-401, P-405, P-408, P-410, P-411, P-603, and P-609.

90-12 90+ ASPHALT MATERIAL. The requirements for this material will be included under the construction specifications.

90+ asphalt material may be used in:

Items P-405, P-603, and P-609.

90-13 CUT-BACK ASPHALT. The rapid curing type cut-back asphalt shall meet the requirements of A. A. S. H. O. Specification M-81. The medium curing type cut-back asphalt shall meet the requirements of A. A. S. H. O. Specification M-82. The grade shall be included in the proposal or shown on the plans.

Cut-back asphalt may be used in:

Items P-204, P-602, P-603, P-604, and P-609.

90-14 TAR. The tar shall meet the requirements of A. A. S. H. O. Specification M-52. The grade shall be indicated in the proposal or shown on the plans.

Tar may be used in:

P-201, P-204, P-216, P-405, and P-602.

90-15 EMULSIFIED ASPHALT. The requirements for emulsified asphalt will be included under the construction specifications.

Emulsified Asphalt may be used in:

Items P-204, P-214, P-215, P-216, P-405, P-603, P-604, and P-609.

90-16 LIQUEFIER. The liquefier shall meet the requirements of A. A. S. H. O. Specification M-83. The grade shall be the light grade unless otherwise indicated in the proposal.

Liquefier will be used in:

Items P-410 and P-411.

90-17 HYDRATED LIME. The hydrated lime shall meet the requirements of A. S. T. M. Designation C-6.

Hydrated Lime may be used in:

Items P-201, P-204, P-215, P-216, P-401, and P-410.

90-18 MINERAL FILLER FOR BITUMINOUS MIXTURES. The mineral filler for bituminous mixtures shall meet the requirements of A. A. S. H. O. Specification M-17. Stone dust shall be required and used with sand bituminous base and surface courses.

Mineral Filler may be used in:

Items P-201, P-204, P-215, and P-401.

90-19 CRUSHED STONE. The requirements for crushed stone will be included in the construction specifications.

Crushed Stone may be used in:

Items P-201, P-204, P-205, P-206, P-208, P-209, P-214, P-215, P-216, P-217, P-302, P-401, P-405, P-410, P-501, P-604, P-609, and P-610.

90-20 CRUSHED SLAG. The requirements for crushed slag will be included in the construction specifications.

Crushed Slag may be used in:

Items P-201, P-204, P-205, P-206, P-208, P-209, P-214, P-216, P-217, P-401, P-405, P-410, P-501, P-609, and P-610.

90-21 GRAVEL. The requirements for gravel will be included in the construction specifications.

Gravel may be used in:

Items P-201, P-204, P-208, P-209, P-213, P-215, P-216, P-217, P-302, P-401, P-405, P-501, and P-609.

90-22 SIZE AND GRADATION REQUIREMENTS FOR COARSE AGGREGATE. The size and gradation requirements for coarse aggregate for designated uses shall meet those shown in the table.

SIZE AND GRADATION REQUIREMENTS FOR COARSE AGGREGATES

Total percent passing sieves having square openings

Size No.	3"	2½"	2"	1½"	1"	¾"	½"	⅜"	No. 4	No. 8	No. 50	No. 100	CAA—PAVING
2	100	90-100	35-70	0-15		0-5							Penetration Macadam, Item 214.
24	100	90-100		25-60		0-10	0-5						Macadam, Items 205 and 206.
3		100	90-100	35-70	0-15		0-5						Penet. Macadam, Item 214. Portland Conc., Item 501.
4			100	90-100	20-55	0-15		0-5					Portland Cement Concrete, Item 501.
57				100	90-100		25-60		0-10	0-5			Portland Cement Concrete, Item 501.
6					100	90-100	20-55	0-15	0-5				Key Stone Mat, Item 405.
67					100	90-100		20-55	0-10	0-5			Portland Cement Concrete, Item 501.
7						100	90-100	40-70	0-15	0-5			Key Stone Mat., Item 405. Penet. Macad., Item 214. Surface Treatment, Item 609.
7A						100	95-100		15-40	10-25	0-5		Asphalt Concrete Surface, Item 410.
8							100	85-100	10-30	0-10		0-2	Penet. Macad., Item 214. Surface Treatment, Item 609.
10								100	85-100			10-30	Screenings, Items 205 and 206.

Size number is that given in A. A. S. H. O. Specification M-43, except 7A.

90-23 FENCES. The material requirements for fences will be given in detail in the construction specifications. The most important materials are listed as follows:

(a) *Classes A, B, C, and D, wire fence.*

(1) The woven wire fencing shall conform to Federal Specification RR-F-221, Type B. All wires shall be two dip, of the size and spacing as shown on the plans.

(2) The barbed wire shall conform to Federal Specification RR-F-221, Type A. All wires shall be two dip, of the size and spacing as shown on the plans.

(3) The wooden posts shall be of the species, quality, dimensions, and treatments as required in Item P-160.

(4) The steel posts shall consist of rail steel meeting A. S. T. M. Designation A-16 or hard grade billet steel meeting A. S. T. M. Designation A-15. The posts shall be of the section, the length, and be galvanized as required on the plans.

Wire fence will be used in:

Item P-160 or P-161.

(b) *Class E, chain link fence.*

(1) The chain link fabric shall meet the requirements of A. S. T. M. Designation A-117. The fabric shall be of the size, dimension, and galvanized as shown on the plans or required in the construction specifications.

(2) The steel posts shall conform to A. S. T. M. Designation A-7 with a minimum copper content of 0.20 percent. The posts shall be of the section, weight, length, and be galvanized as shown on the plans.

Chain link fence will be used in:

Item P-162.

(c) *Class F, wood picket fence.*

The wooden pickets and posts shall meet all the requirements of Item P-163.

Wood picket fence will be used in:

Item P-163.

90-24 DRAINAGE PIPE. The material requirements for drainage pipe shall be as follows:

(a) *Clay pipe for underdrains, storm sewers, and culverts.*

The pipe shall conform to A. A. S. H. O. Specification M-65. If the pipe is required to be perforated, the perforations shall conform to Item D-705.

Clay pipe will be used in:

Item D-701 or D-705.

(b) *Concrete pipe for underdrains, storm sewers, and culverts.*

The pipe shall conform to A. A. S. H. O. Specifications M-86, M-87, or M-41. If the pipe is required to be perforated, the perforations shall conform to Item D-705.

Concrete pipe will be used in:

Item D-702 or D-705.

(c) *Corrugated metal pipe for underdrains, storm sewers, or culverts.*

The pipe shall conform to A. A. S. H. O. Specification M-36. If the pipe is required to be bituminous-coated or coated and paved, the coating and pavement shall conform to Item D-703. If the pipe is required to be perforated, the perforations shall conform to Item D-705.

Corrugated metal pipe will be used in:

Item D-703 or D-705.

(d) *Cast iron pipe for storm sewers and culverts.*

The pipe shall conform to A. A. S. H. O. Specification M-64.

Cast iron pipe will be used in:

Item D-704.

90-25 DRAINAGE STRUCTURES. The material requirements for drainage structures shall be as follows:

(a) *Brick.* The brick shall conform to A. A. S. H. O. Specification M-91.

(b) *Concrete.* Concrete materials shall conform to Item P-610.

(c) *Mortar.* The Portland cement for mortar for masonry and similar work shall conform to A. S. T. M. Designation C-150, Type 1. The sand shall conform to A. A. S. H. O. Specification M-45.

(d) *Castings.* The castings for frames, covers, and gratings shall conform to one of the following:

1. Gray iron castings shall conform to A. A. S. H. O. Specification M-105.

2. Malleable iron castings shall conform to A. A. S. H. O. Specification M-106.

3. Steel castings shall conform to A. A. S. H. O. Specification M-103.

(e) *Steel Grates and Frames.* Steel for grates and frames shall be structural steel conforming to A. A. S. H. O. Specification M-94. The steel, after fabrication, shall be galvanized, meeting A. A. S. H. O. Specification M-111.

(f) *Masonry Stones.* Masonry stones shall conform to Item D-753.

(g) *Gutter Stones.* Gutter stones shall conform to Item D-755.

The details for all material and construction requirements will be found in the items for different types of drainage structures as follows:

Items D-751, D-752, D-753, D-754, and D-755.

SECTION 91

TURFING MATERIAL DETAILS

91-01 GENERAL. These specifications cover the requirements of materials used for turfing or other plantings on airports. However, it is readily recognized that, due to a wide variation in climatic and soil conditions throughout the country, many different types and species of materials will be required for the establishment of turf and in landscaping. Some materials, such as species of grass seed, trees, shrubs, vines, etc., cannot be prescribed as standards but will have to be covered by special provisions for each construction project. In such cases only very general requirements can be enumerated in this section. The special provisions which become a part of the turfing specifications may add materials not listed in the standard specifications or delete any of those included therein.

Only approved materials conforming to the requirements of the specifications shall be used in the work. All materials may be subject to inspection and tests at any time during the progress of their preparation or use. Representative preliminary samples of the materials shall be submitted by the contractor, when required, for examination and test. Materials shall be stored and handled so as to insure the preservation of their quality and fitness for use. Testing and sampling of seed and fertilizers shall be done in accordance with the latest "Rules and Regulations Under the Federal Seed Act," in effect as of the date of the purchase order, and using approved methods in determining compliance with applicable State fertilizer laws, respectively.

91-02 SEEDS. The seed mixture to be furnished and the minimum percentage by weight of pure live seed of each species in each lot of seed and the maximum percentage of weed seed shall be as stated in the special provisions. When the total percentage of pure live seed furnished is higher than the minimum required, the ratio of seed of the named species shall be approximately the same as that stated in the special provisions. All seed used shall be labeled in accordance with U. S. Department of Agriculture "Rules and Regulations Under the Federal Seed Act," in effect on the date of the purchase order. All seed shall be furnished in standard containers, unless exception is granted by the engineer. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

Seed will be used in:

Items T-901 and T-902.

91-03 LIME. Lime shall be ground limestone containing not less than eighty-five (85) percent of total carbonates, and shall be ground to a fineness that ninety (90) percent will pass through a No. 20 mesh sieve and fifty (50) percent will pass through a No. 100 mesh sieve. Any material not meeting the requirements may be rejected.

Lime may be used in:

Items T-901, T-903, T-904, and T-906.

91-04 FERTILIZER. Fertilizers shall be commercial carriers of available plant food elements or combinations thereof, either as organic or inorganic materials, as stated in the special provision, and shall conform to the applicable State fertilizer laws. The fertilizer shall be delivered in bags or other convenient standard containers with name of material, name of manufacturer, net weight of contents, and analysis stamped on each container.

Any material which has become caked or otherwise damaged, making it unsuitable for use, will not be accepted.

Fertilizer may be used in:

Items T-901, T-903, T-904, and T-906.

91-05 SOILS FOR REPAIR. The soil for fill and topsoiling of areas to be repaired shall be at least of equal quality to that which exists in areas adjacent to the areas to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent sowing, compacting, or establishment operations, and shall be approved by the engineer before being placed.

Soils for Repair may be used in:

Items T-901, T-902, T-903, T-904, and T-906.

91-06 SPRIGS. Sprigs shall be the healthy, living, stems (stolons or rhizomes) of the grass species, stated in the special provision, and attached roots without adhering soil, obtained from approved sources where the sod is heavy and thickly matted. The presence of weeds or other material which might be detrimental to the proposed planting will be cause for rejection of sprigs.

Sprigs will be used in:

Item T-903.

91-07 WATER. The water shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass. It shall be subject to the approval of the engineer prior to use.

Water will be used in:

Items T-903, T-904, and T-906.

91-08 SODDING. Sod, when used for solid, strip, or spot sodding will be as described in standard specifications nor sodding, Item T-904.

Sod will be used in:

Item T-904.

91-09 TOPSOIL. Topsoil, when furnished by the contractor, shall be a natural friable soil, possessing characteristics of representative productive soils in the vicinity. The topsoil shall be obtained from naturally well-drained areas and be reasonably free from subsoil, clay lumps, stones, stumps, roots, or similar objects larger than two (2) inches in greatest diameter, brush, objectionable weeds or litter, excess acid or alkali, or any other material or substance which may be harmful to plant growth or a hindrance to subsequent smooth grading, planting, and maintenance operations.

Topsoil will be used in:

Item T-905.

91-10 TOPSOIL WITH GRASS. Topsoil with grass, when furnished by the contractor, shall be a natural, friable, soil obtained from approved areas covered with a vigorous growth of the grass species stated in the special provisions. The grass shall have a healthy, thickly matted root system, and shall be contained in the topsoil when it is moved. The topsoil containing grass shall be reasonably free from subsoil, clay lumps, stones, stumps, roots or other similar objects larger than two (2) inches in greatest diameter, brush, objectionable weeds or other litter, and any other material or substance which may be harmful to plant growth or a hindrance to subsequent smooth grading, planting, and maintenance operations.

Topsoil with grass will be used in:

Item T-906.

91-11 MULCH MATERIAL. Mulch material shall be as specified in the specification for mulching or as shown on the plans. Low grade, musty, spoiled, partially rotted hay, straw, or other materials unfit for animal consumption will be acceptable. Mulch materials which contain matured seed of species which would volunteer and be detrimental to proposed overseeding, or to surrounding farm land, will not be acceptable. Straw or other mulch material which is fresh and excessively brittle, or which is in such an advanced stage of decomposition as to smother or retard the grass, will not be acceptable.

Mulch material will be used in:

Item T-908.

91-12 LANDSCAPING MATERIALS. Materials such as trees, shrubs, vines, or guying, staking, or wrapping materials used in plantings at airports will be as described in the Standard Specifications for Planting Trees, Shrubs, and Vines, Item T-950, or Tree Wells and Root Protection, Item T-951.

SECTION 92

LIGHTING MATERIAL DETAILS

92-01 GENERAL. The materials included under this heading are those needed for airport lighting and electrical distribution items. The construction specifications (L-100 series) describe the quality requirements of the lighting and distribution equipment in full detail by referencing material specifications. These material specifications define the material and establish a means for local inspection or enable the manufacturer to obtain prior approval from the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C.

All items of lighting equipment, and some items of electrical distribution equipment, require this approval by the Office of Airports before installation. Where this approval is required, but is not secured by the manufacturer, the item must be inspected in accordance with the detail inspection and sample requirements outlined in the material specification. Notice of these approvals will be furnished by the Office of Airports, Civil Aeronautics Administration, to the engineer by means of a list covering the approved airport lighting equipment.

Other electrical distribution equipment, and other material not requiring prior approval, must conform to the requirements of the construction specification. When required by the engineer, representative samples of the materials shall be submitted and approved by the engineer before delivery or use is started.

All equipment and materials shall be handled and stored so as to insure the preservation of their quality and fitness for use, and shall be so located as to facilitate prompt inspection.

All equipment and materials may be subjected to inspection and tests at any time prior to, during, or after their installation.

A list of the more important items follows. The asterisk indicates that the item must have approval by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C.

The specifications listed in Division V of this book are construction and installation specifications only. Copies of the following material specifications may be obtained from the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C.

92-02* AIRPORT 36-INCH ROTATING BEACON. The airport rotating beacon shall conform to Specification CAA-291, "Specification for Beacons, 36-inch, Double-End Type," with clear and

green lenses, except less code flashing mechanism, unless otherwise specified. Where specified, the code-flashing mechanism shall consist of a contactor and cam cut to flash the code signal assigned to the airport.

92-03* AIRPORT CODE BEACON. The airport code beacon shall conform to Specification CAA-446, "Specification for Code Beacons," style III, with green color filters.

92-04 AIRPORT BEACON TOWER. The steel beacon tower shall conform to Specification AN-T-11, "Tower; Aerial Navigation Beacon," of the height specified on the proposal, less wind cone bracket, unless otherwise specified.

Heights of 51, 62, 75, 91, 108, 129, and 152 feet are standard.

92-05* AIRPORT FLUSH MARKER LIGHTS. Flush marker lights shall conform to Specification AN-L-9, "Army-Navy Aeronautical Specification—Lamp Assembly; Runway Marker," in the quantity specified in the proposal; each unit to be complete with top assembly of the type and class specified in the proposal, with the color filters specified in the proposal, and with a type AN-2512-12 shallow base assembly complete with bolts, gasket, and plywood cover, unless otherwise specified. Where specified, the base assembly shall consist of type AN-2512-2 deep base assembly complete with bolts, gasket, and plywood cover.

The combat hood is not required.

92-06* AIRPORT CONE-MOUNTED LIGHTS. The cone-mounted boundary, range, or obstruction lighting units shall conform in all respects to Specification AN-L-10, "Army-Navy Aeronautical Specification—Lamp Assembly; Boundary and Obstruction Marker," in the quantity specified in the proposal; each unit to be complete with globe, fitting, cone, and cone mounting and, if required, filter as specified by AN part number in the proposal.

The combat hood is not required.

92-07* AIRPORT OBSTRUCTION LIGHTS. The obstruction lights shall conform to both or either of the following as required and as stipulated in the proposal:

(a) Specification AN-L-10, "Army-Navy Aeronautical Specification—Lamp Assembly; Boundary and Obstruction Marker," in the quantity specified in the proposal; each unit to be complete with globe(s) and fitting as specified by AN part number in the proposal.

The combat hood is not required.

(b) Specification AN-L-31, "Army-Navy Aeronautical Specification—Lamp Assembly; Disconnecting Obstruction Marker," in the quantity specified in the proposal; each unit consisting of the following parts:

1. Obstruction Light Disconnecting Fitting Assembly consisting of two AN-2541-2 prismatic or AN-2541-12 fresnel globes, two AN-2547-5 top sections and one AN-2548-2 base.

2. Disconnecting Hangar Assembly with adapter, cables, and all fittings necessary for the completed installation and:

- a. With accessories for use up to 100-foot mounting height;
or
- b. With accessories for use up to 200-foot mounting height.
- c. Complete with winch assembly as specified in the proposal.

92-08* AIRPORT 12-FOOT WIND CONE. The wind cone shall conform to Specification AN-I-23, "Army-Navy Aeronautical Specification—Indicator Assemblies; Wind Cone; Unlighted and Externally Lighted," and shall be one of the following, as specified in the proposal:

Standard types and classes are:

- AN-2531-1 Type I (beacon tower mounted), Class A (unlighted).
- AN-2531-2 Type I (beacon tower mounted), Class B (lighted).
- AN-2531-3 Type II (pipe mounted), Class A (unlighted).
- AN-2531-4 Type II (pipe mounted), Class B (lighted).

92-09 AIRPORT UNDERGROUND CABLE FOR LARGE AIRPORTS. Underground cable shall conform to the requirements of Specification CAA-701, "Cable; Electrical; Synthetic Rubber Insulated; Non-Metallic Armor," Type IC or Type IIC, unless otherwise specified. Cable size, number of conductors, and service voltage shall be as specified on the plans and/or in the proposal.

92-10 AIRPORT UNDERGROUND ELECTRICAL DUCT. Underground duct shall conform to one of the following, as required and as stipulated in the proposal.

(a) *Bituminous Fiber Duct.* Bituminous fiber duct and fittings shall conform to the requirements of Federal Specification W-C-581, and shall be one of the following, as specified in the proposal:

1. Type I for concrete encasement.
2. Type II for direct burial.

(b) *Asbestos Cement Duct.* Asbestos cement duct and fittings shall conform to the requirements of Federal Specification W-C-571, and shall be one of the following, as specified in the proposal.

1. Type I for concrete encasement.
2. Type II for direct burial.

(c) *Terra Cotta Duct.* Terra cotta duct and fittings shall be of first-grade commercial quality.

92-11* AIRPORT WIND TEE. The tee shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-808, "Lighted Wind Tee."

92-12* ROTATING BEACON FOR SMALL AIRPORTS. The beacon shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-801, "Beacon for Small Airports."

92-13* AIRPORT ELEVATED MARKER LIGHTS, BASE-MOUNTED TYPE. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, as conforming to the requirements of Specification L-802, "Specification for Elevated Runway and Strip Marker Lights," and shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with lens assembly of the color specified in the proposal, fitting, cone, base-mounting assembly, transformer, and a base. The type of base shall be specified in the proposal and shall conform to one of the following:

- a. Shallow-base assembly, Type AN-2512-12 or Type AN-2512-11, complete with bolts, gasket, and cover.
- b. Deep-base assembly, Type AN-2512-2 or Type AN-2512-1, complete with bolts, gasket, and cover.
- c. Base assembly as shown in the proposal complete with bolts, gasket, and cover. The base flange shall provide mounting dimensions interchangeable with bases AN-2512-12 and 2512-2.

92-14* AIRPORT ELEVATED MARKER LIGHTS, STAKE-MOUNTED TYPE. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-802, "Specification for Elevated Runway and Strip Marker Light," and shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fitting, cone, stake-mounting assembly, and transformer or junction box.

92-15* AIRPORT ELEVATED MARKER LIGHTS, COLUMN-MOUNTED TYPE. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-802, "Specification for Elevated Runway and Strip Marker Lights," and shall be supplied in the quantity specified on the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fitting, cone, column-mounting assembly, and a transformer or junction box.

92-16* ILLUMINATED WIND CONE FOR SMALL AIRPORTS. The illuminated wind cone shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-807, "Specification for Illuminated Wind Cone for Small Airports," and shall be supplied in the quantity specified in the proposal. The illuminated wind cone shall be completed with hinged steel pole, a shaft assembly with bearing supports, a fabric cone, a lighting fixture assembly, and an obstruction light.

92-17 UNDERGROUND CABLE FOR SMALL AIRPORTS. Underground cable shall conform to the requirements of Specification CAA-701, "Cable; Electrical; Synthetic Rubber Insulated; Non-

Metallic Armor," Type IC or Type IIC, except the sheath may be not less than $\frac{1}{64}$ inch. When $\frac{1}{64}$ -inch sheath is used on single conductor leads, the sheath shall adhere directly to the insulation. Cable size, number of conductors, and service voltage shall be as specified on the plans and/or in the proposal.

92-18* AIRPORT HIGH INTENSITY RUNWAY MARKER LIGHT. The high-intensity runway light shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, as conforming to the requirements of one of the following specifications: L-818, "Controllable Beam Bi-Directional High-Intensity Runway Light"; L-819, "Fixed Focus Bi-Directional High-Intensity Runway Light"; or L-820, "Fixed Focus, Unidirectional High-Intensity Runway Light." The high-intensity lights shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fixture, mounting assembly, and, if required, a transformer. The mounting assembly shall consist of a fixture-supporting column with breakable insert, base adapter plate, and one of the following base assemblies, as specified in the proposal:

- a. Shallow-base assembly, Type AN-2512-12 or Type AN-2512-11, complete with bolts, gasket, and cover.
- b. Deep-base assembly, Type AN-2512-2 or Type AN-2512-1, complete with bolts, gasket, and cover.
- c. Base assembly, as shown on the plans, complete with bolts, gasket, and cover. The base flange shall provide mounting dimensions interchangeable with bases AN-2509 and AN-2513.

92-19 AIRPORT LIGHT DUTY OBSTRUCTION LIGHT. The light duty obstruction light shall be a type approved by the Civil Aeronautics Administration as conforming to the requirements of Specification L-810, "Obstruction Light, Light Duty." The obstruction lights shall be single or double types and for series or multiple circuits as specified in the proposal, and shall be supplied in the quantity specified in the proposal.

151-2.3 CLEARING AND GRUBBING

CONSTRUCTION METHODS

The area to be cleared and grubbed shall be marked on the plans to be cleared and grubbed and this area shall be marked on the ground by the engineer. The clearing and grubbing shall be done at a satisfactory distance ahead of the existing operations. All spoil materials removed by clearing or grubbing shall be disposed of by burning or by removal to a approved disposal area and shall be within six (6) inches of the ground and shall be allowed to remain. Top roots and other projections over one-

DIVISION III—PAVING CONSTRUCTION DETAILS

EARTHWORK

ITEM P-151 CLEARING AND GRUBBING

DESCRIPTION

151-1.1 This item shall consist of clearing, and/or clearing and grubbing, including the disposal of materials, for all areas within the limits designated on the plans or as required by the engineer.

Clearing shall consist of the cutting and removal of all trees, stumps, brush, logs, the removal of fences and other loose or projecting material from the designated areas. The grubbing of stumps and roots will not be required.

Clearing, when so designated, shall consist of the cutting and removal of isolated single trees or isolated groups of trees. The cutting of all the trees of this classification shall be in accordance with the requirements for the particular area being cleared, or as shown on the plans, or as directed by the engineer. The trees shall be considered isolated when they are forty (40) feet or more apart, with the exception of a small clump of approximately five trees or less.

Clearing and grubbing shall consist of clearing the surface of the ground of the designated areas of all trees, down timber, logs, snags, brush, undergrowth, heavy growth of grass or weeds, fences, structures, debris and rubbish of any nature, natural obstructions or such material which in the opinion of the engineer is unsuitable for the foundation of the runways or other required structures, including the grubbing of stumps, roots, matted roots, foundations, and the disposal from the project of all spoil materials resulting from clearing and grubbing by burning or otherwise.

CONSTRUCTION METHODS

151-2.1 GENERAL. The areas denoted on the plans to be cleared and/or cleared and grubbed under this item shall be staked on the ground by the engineer. The clearing and grubbing shall be done at a satisfactory distance ahead of the grading operations.

All spoil materials removed by clearing or by clearing and grubbing shall be disposed of by burning or by removal to approved disposal

areas. Piles for burning shall be placed either in cleared area near the center or in adjacent open spaces where no damage to trees or other vegetation will occur. The contractor will be responsible for controlling fires in compliance with all Federal and State laws and regulations relative to building fires at the site.

If the plans or the specifications require the saving of merchantable timber, the contractor shall trim the limbs and tops from such designated trees, saw the same into suitable log lengths, and make the material available for removal by other agencies.

Any blasting necessary shall be done at the contractor's responsibility and the utmost care shall be taken not to endanger life or property.

The removal of existing structures and utilities required to permit the orderly prosecution of the work will be accomplished by local agencies unless otherwise shown on the plans. Whenever a telephone or telegraph pole, pipe line, conduit, sewer, roadway, or other utility is encountered and must be removed or relocated to permit the completion of the project, the contractor will so advise the engineer who will notify the proper local authority or owner and attempt to secure prompt action.

151-2.2 CLEARING. The contractor shall clear the staked or indicated area of all objectionable materials. Trees unavoidably falling outside the specified limits must be cut up, removed and disposed of in a satisfactory manner. In order to minimize damage to trees that are to be left standing, trees shall be felled toward the center of area being cleared. The contractor shall preserve and protect from injury all trees not required to be removed.

The trees, stumps, and brush shall be cut to a height of not more than twelve (12) inches above the ground. The grubbing of stumps and roots will not be required.

When isolated trees are designated for clearing, the trees shall be classed in accordance with the butt diameter size as measured at a point eighteen (18) inches above the ground level at the tree or at a designated height in the proposal.

Fences shall be removed and disposed of when directed by the engineer. Fence wire shall be neatly rolled and the wire and posts stored on the airport, if same are to be used again or stored at a designated location as directed by the engineer.

151-2.3 CLEARING AND GRUBBING. In areas designated to be cleared and grubbed, all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials shall be removed, except where embankments exceeding three and one-half (3½) feet in depth are to be made. In cases where such depth of embankments are to be made, all unsatisfactory materials shall be removed, but sound trees, stumps, and brush can be cut off within six (6) inches above the ground and allowed to remain. In like manner the height of the embankments in areas to be paved shall exceed five (5) feet before the sound trees and stumps are cut within six (6) inches of the ground and allowed to remain. Tap roots and other projections over one and one-

half ($1\frac{1}{2}$) inches in diameter shall be grubbed out to a depth of at least eighteen (18) inches below the finished subgrade elevation.

All holes remaining after the grubbing operation in embankment areas and in excavation areas less than two (2) feet in depth shall have the sides broken down or leveled if necessary to flatten out the slopes, refilled with acceptable material, moistened and properly compacted in layers by tampers, rollers, or construction equipment to the density as required in the grading specifications.

METHOD OF MEASUREMENT

151-3.1 The quantities of clearing or clearing and grubbing as shown by the limits on the plans or as ordered by the engineer shall be the number of acres or fractions thereof, of land specifically cleared or cleared and grubbed, unless lump-sum bid is specified in the proposal.

When isolated trees are designated for clearing, the quantities of trees as determined in accordance with ranges of butt-diameter size measured at a point eighteen (18) inches above the ground level at the tree shall be paid for according to the schedule of sizes as follows:

From 0 to $2\frac{1}{2}$ feet, butt diameter.

From $2\frac{1}{2}$ feet to 5 feet, butt diameter.

For 5 feet or more, butt diameter.

BASIS OF PAYMENT

151-4.1 The item of "Clearing" shall be paid for at the contract unit price bid per acre or lump sum as specified in the bid schedule, which payment shall include full compensation for all equipment, tools, materials, labor, and incidentals necessary to complete the work.

151-4.2 The item of "Clearing for Isolated Trees" shall be paid for at the contract unit price bid as specified in the bid schedule for each tree removed of the size determined as provided above for butt diameter. The payment shall include the cutting-up into lengths and/or the disposal of the trees and the full compensation for all equipment, tools, materials, labor, and incidentals necessary to complete the work.

151-4.3 The item of "Clearing and Grubbing" shall be paid for at the contract unit price bid per acre or lump sum as specified in the bid schedule, which payment shall include full compensation for all equipment, tools, materials, labor, and incidentals necessary to complete the work.

Payment will be made under:

Item P-151-4.1 Clearing—per acre.

Item P-151-4.2 Clearing for Isolated Trees.

From 0 to $2\frac{1}{2}$ feet butt diameter, per tree.

From $2\frac{1}{2}$ to 5 feet butt diameter, per tree.

For 5 feet or more butt diameter, per tree.

Item P-151-4.3 Clearing and Grubbing—per acre.

ITEM P-152 EXCAVATION AND EMBANKMENT

DESCRIPTION

152-1.1 DESCRIPTION. This item shall consist of excavating, removing, and satisfactorily disposing of all materials within the limits of the work required to construct the landing strips, runways, taxiways, aprons, intermediate and other areas for drainage, building construction, parking, or other purposes, in accordance with these specifications and in conformity with the dimensions and typical section shown on the plans and with the lines and grades established by the engineer.

All suitable material taken from excavation shall be used in the formation of embankment, subgrade, and for backfilling as indicated on the plans or as directed by the engineer.

In case the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development, or wasted as directed. In case the volume of excavation is not sufficient for constructing the fill to the grades indicated, the deficiency shall be supplied from borrow sources at the locations within the airport or other authorized areas.

152-1.2 CLASSIFICATION. All material excavated shall be defined as "Unclassified Excavation" unless, in the proposal form, prices are asked and bids are taken for "Solid Rock Excavation" and "Common Excavation."

"Unclassified Excavation" shall include all excavation performed under this item regardless of the material encountered.

"Solid Rock Excavation," when this classification is provided for in the proposal, shall include all solid rock in ledges, in bedded deposits, in unstratified masses; also conglomerate deposits so firmly cemented as to present all the characteristics of solid rock and which cannot be removed without drilling and blasting. All boulders containing a volume of more than one-half ($\frac{1}{2}$) cubic yard will be classified as "Solid Rock Excavation."

"Common Excavation," when this classification is provided for in the proposal, shall consist of all excavation not included in "Solid Rock Excavation."

Frozen condition of any of the different classified materials taken from excavation shall constitute no claim for higher classification or for extra work on the part of the contractor.

CONSTRUCTION METHODS

152-2.1 GENERAL. The rough excavation shall be carried to such depth that sufficient material will be left above the designated grade to allow for compaction to this grade. Likewise, on embankments, sufficient material shall be placed above the designated grade to allow for compaction and settlement. Should the contractor through negligence or other fault excavate below the designated lines, he shall replace such excavation with approved materials, in an approved manner and condition, at his own expense. The engineer shall have complete control over the excavation, moving, placing, and disposition of all material, and shall determine the suitability of material to be placed in embankments. All material determined unsuitable shall be disposed of in waste areas or as directed. In general, the layer of topsoil shall not be used in fills or in subgrades but shall be handled and placed as directed.

The contractor shall inform and satisfy himself as to the character, quantity, and distribution of all material to be excavated. No payment will be made for any excavated material which is used for purposes other than those designated. All spoil areas shall be leveled to a uniform line and section and shall present a neat appearance before project acceptance. The surface elevation of spoil areas shall not extend above the surface elevation of adjacent or contiguous usable areas of the airport.

Those areas outside of the pavement areas in which the top layer of soil material becomes compacted, due to hauling or to any other activity of the contractor, shall be scarified and disced to a depth of four (4) inches, as directed to loosen and pulverize the soil.

If it is necessary in the prosecution of the work to interrupt existing surface drainage, sewers, or underdrainage, conduits, utilities, or similar underground structures, or parts thereof, the contractor shall be responsible for and shall take all necessary precautions to protect and preserve or provide temporary services for same. When such facilities are encountered, the contractor shall notify the engineer who shall arrange for their removal if necessary. The contractor shall, at his own expense, satisfactorily repair all damage to such facilities or structures which may result from any of his operations or from negligence during the period of the contract.

152-2.2 EXCAVATION. Excavation shall be performed at such places as are indicated on the contract plans, to the lines, grades, and elevation shown or as directed by the engineer, and shall be made in such manner that the requirements for formation of embankments can be followed. No excavation shall be started until the engineer has taken cross-sectional elevations and measurements of the existing ground surface and has staked out the proposed work. All material encountered of whatever nature within the limits indicated shall be removed and disposed of as directed. During the process of excavation, the grade shall be maintained in such condition that it will be well drained at all times. When directed, temporary drains and

drainage ditches shall be installed to intercept or divert surface water which may affect the prosecution or condition of the work.

The excavation material shall be handled in such a manner as to allow the selected material to be properly placed in the embankment and in the capping of pavement subgrades as determined from the soil profile and soil characteristics. This material shall be deposited within the designated areas of the airport as shown on the plans or as directed by the engineer.

If at the time of excavation it is not possible to place any material in its proper section of the permanent construction, it shall be stockpiled in approved areas for later use.

Where rock, shale, clay, hardpan or other material unsatisfactory for subgrade is encountered, it shall be excavated to a depth of at least twelve (12) inches, or such greater depth as the engineer may direct, below the contemplated surface of the subgrade. All material so excavated shall be paid for at the contract unit price per cubic yard for "Unclassified Excavation" or for "Common Excavation" or for "Solid Rock Excavation" as the case may be, when the classification for the last two items is provided for in the proposal. The portion so excavated shall be refilled with suitable selected material as specified, obtained from the grading operations or borrow and thoroughly compacted by rolling as specified. The necessary refilling will constitute a part of the embankment. Where rock cuts are made and refilled with selected material or where trenching out is done to provide for a course of pavement, the depths thus created shall be ditched at frequent intervals to provide adequate outlets for drainage.

The contractor shall make the distribution as indicated on the plans, and the widening or narrowing of the section, raising or lowering of the grade to avoid haul will not be permitted. The right is reserved to make minor adjustments or revisions in lines or grades if found necessary as the work progresses, due to discrepancies on the plans or in order to obtain satisfactory construction.

Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the engineer. The engineer shall determine if the displacement of such material was unavoidable and his decision shall be final. All overbreak shall be removed by the contractor and disposed of as directed. Payment will not be made for removing and disposing of overbreak which the engineer determines to have been avoidable. Unavoidable overbreakage will be classified as "Unclassified Excavation" except when the contract provides for the classification of "Common Excavation" and "Solid Rock Excavation" in which case unavoidable overbreakage from slides will be classified as such.

The removal of existing structures and utilities required to permit the orderly prosecution of the work will be accomplished by local agencies unless otherwise shown on the plans. All existing foundations shall be excavated for at least two (2) feet below the top of the subgrade and the material disposed of as directed. All foundations

thus excavated shall be backfilled with suitable material and compacted.

In cut areas the top of the subgrade under areas to be paved shall be sacrificed and compacted to a minimum depth of six (6) inches to not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. When the required density cannot be obtained the material shall be undercut and replaced with suitable material as directed. The depth of the undercut necessary shall be determined by the engineer. The material placed to refill the undercut portion shall be handled and compacted as specified for embankments.

Stones or rock fragments larger than four (4) inches in their greatest dimension will not be permitted in the top six (6) inches of the subgrade. The finished grading operations conforming to the typical cross section shall be completed and maintained at least one thousand (1,000) feet ahead of the paving operations.

In cuts, all loose or protruding rocks on the back slopes shall be barred loose or otherwise removed to line or finished grade of slope. All cut and fill slopes shall be uniformly dressed to the slope, cross section and alignment shown on the plans, or as directed by the engineer.

Blasting, when necessary, will be permitted only when proper precautions are taken for the protection and safety of all persons, the work, and the property. All damage done to the work or property shall be repaired at the contractor's expense. All operations of the contractor in connection with the transportation, storage, and use of explosives shall be approved by the engineer. Any approval given will not relieve the contractor of his responsibility in blasting operations.

152-2.3 BORROW EXCAVATION. When provided for the proposal, borrow excavation shall consist of excavation made from borrow areas within the limits of the airport property outside the normal grading limits, and/or from areas outside the airport, when specified, for the completion of the embankments or for other purposes. Borrow area or areas within the airport property from which borrow may be obtained will be designated. Borrow excavation shall be made only at these designated locations and within the horizontal and vertical limits as staked or as directed. On completion of borrow operations, the borrow area shall be finished to a neat and uniform grade acceptable to the engineer.

When borrow sources are outside the boundaries of the airport property, it shall be the contractor's responsibility to locate and obtain the supply subject to the approval of the engineer. The contractor shall notify the engineer sufficiently in advance of the beginning of excavation in order that necessary measurements and tests can be made. All objectionable material shall be disposed of as directed. All borrow pits shall be opened up immediately to expose the vertical face of various strata of acceptable material to obtain a uniform product. Borrow pits shall be excavated to regular lines so as to permit accurate

measurements, and shall be drained and left in a neat and presentable condition with all slopes dressed uniformly.

The borrow excavation shall be handled and placed as specified in these specifications for excavation and embankment.

152-2.4 DITCH EXCAVATION. Ditch excavation shall consist of excavating for drainage ditches such as intercepting, inlet, outlet, offtake, temporary levee construction, or any other type as designed or as shown on the plans. The work shall be performed in the proper sequence with the other construction. The location of all ditches or levees will be established on the ground. All satisfactory material shall be placed in fills; unsatisfactory material shall be placed in spoil areas or as directed. Waste or surplus material shall be disposed of as shown on plans or as directed. Intercepting ditches shall be constructed prior to the starting of adjacent excavation operations. All handwork as is necessary shall be performed to secure a finish true to line, elevation, and cross-section as designated.

The ditches constructed on the project shall be maintained to the required cross section and shall be kept free from debris or obstructions until the project is accepted. Where necessary, sufficient openings shall be provided through spoil banks to permit drainage from adjacent lands. Unless otherwise specified, no separate payment will be made for ditch excavation other than for the material removed which will be paid for at the unit price for "Unclassified Excavation" or for "Common Excavation" or "Solid Rock Excavation," as the case may be, if the proposal includes classification of these excavated materials.

152-2.5 PREPARATION OF EMBANKMENT AREA. Embankment areas shall be cleared and grubbed in accordance with the provisions and requirements in Item P-151. All depressions or holes below the ground surface, whether caused by grubbing or otherwise, shall be back-filled with suitable material and compacted to the ground surface before the construction of the embankment will be permitted to start.

Immediately prior to the placing of the fill materials, the entire area upon which the embankment is to be placed, except where limited by rock, shall be scarified and broken by means of a disc harrow or plow or other approved equipment to a depth of six (6) inches. Scarifying shall be done approximately parallel to the axis of the fill. All roots, debris, large stones, or objectionable material that would cause interference with the compaction of the foundation or fill shall be removed from the area and disposed of as directed. A thin layer (approximately three (3) inches) of the fill material shall be spread over the scarified foundation and the whole area compacted as required in the specifications.

Where embankments are to be placed on natural slopes steeper than 3 to 1, horizontal benches shall be constructed as shown on the plans or as directed by the engineer. Suitable excavated material shall be incorporated in embankments. Payment will be made for the material excavated at the unit price for grading.

No direct payment shall be made for the work performed under this section. The necessary clearing and grubbing and the yardage removed or used will be paid for under the respective item of work.

152-2.6 STRIPPING. All vegetation such as brush, heavy sods, heavy growth of grass, decayed vegetable matter, rubbish, and any other unsuitable material within the area upon which embankment is to be placed, shall be stripped or otherwise removed before the embankment is started, and in no case shall such objectionable material be allowed in or under the embankment. No direct payment will be made for stripping as such. The yardage removed and disposed of will be paid for at the contract unit price per cubic yard for "Unclassified Excavation" or for "Common Excavation" when the latter classification is provided for in the proposal.

152-2.7 FORMATION OF EMBANKMENTS. Embankments shall be formed of satisfactory materials placed in successive horizontal layers of not more than eight (8) inches in loose depth for the full width of the cross section.

The grading operations shall be so conducted and the various soil strata shall be placed so as to produce a soil structure as shown on the typical cross section, or as directed. All materials entering the embankment shall be reasonably free of organic matter such as leaves, grass, roots, and other objectionable material. Soil, granular material, shale, and any other material permitted for use in embankment shall be spread in successive layers as specified.

The operations on earth work shall be suspended at any time when satisfactory results cannot be obtained on account of rain, freezing weather, or other unsatisfactory conditions of the field. At all times the contractor shall drag, blade, or slope the embankment to provide proper surface drainage.

The material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Wetting or drying of the material and manipulation to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankment thus affected shall be delayed until the material has dried to the required moisture content. Sprinkling shall be done with sprinkling wagons, pressure distributors, or other approved equipment that will sufficiently distribute the water. Sufficient equipment to furnish the required water shall be available at all times. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials and moisture content will be made to construct the embankment.

Rolling operations shall be continued until the embankment is compacted to not less than ninety (90) percent of the maximum density at optimum moisture as determined by the CAA compaction control tests T-611 for the class of airport involved. Under all proposed paving areas as shown on the plans and for a depth of nine (9) inches below the surface of the subgrade the embankment shall be compacted

to not less than ninety-five (95) percent of the maximum density at optimum moisture as determined by the CAA compaction control tests T-611 for the class of airport involved. On all areas outside of the pavement areas, no compaction will be required on the top four (4) inches. Any areas inaccessible to a roller shall be consolidated and compacted by mechanical tampers.

During construction of the embankment, the contractor shall route his equipment at all times both when loaded and when empty over the layers as they are placed and shall distribute the travel evenly over the entire width of the embankment. The equipment shall be operated in such manner that hardpan, cemented gravel, clay, or other chunky soil material will be broken up into small particles and become incorporated with the other material in the layer.

In the construction of embankments, starting layers shall be placed in the deepest portion of the fill, and, as placement progresses, layers shall be constructed approximately parallel to the finished pavement grade line.

When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portion of the embankment and the other material shall be incorporated under the future paved areas. Stones or fragmentary rock larger than four (4) inches in their greatest dimension will not be allowed in the top six (6) inches of the subgrade. Rock fill shall be brought up in layers as specified or as directed and every effort shall be exerted to fill the voids with the finer material to form a dense, compact mass. Rock or boulders shall not be disposed of outside of the excavation of embankment areas except at places and in the manner designated by the engineer.

Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material.

The contractor shall be responsible for the stability of all embankments made under the contract and shall replace any portion which, in the opinion of the engineer, has become displaced due to carelessness or negligence on the part of the contractor.

There will be no separate measurement or payment for compacted embankment, and all costs incidental to placing in layers, compacting, discing, mixing, sloping, and other necessary operations of the embankments will be included in the contract price for excavation, borrow, or other items.

In case of stockpiling of excavated material and later rehandling of such material is directed by the engineer in order to produce the specified subgrade structure, the material so rehandled will be paid for at the contract unit price per cubic yard for "Unclassified Excavation" or "Common Excavation."

152-2.8 EQUIPMENT. (a) *Grading.* The contractor may use any type of earth-moving equipment he may desire or has at his disposal, provided equipment is in a satisfactory condition and of such capacity that the grading schedule can be maintained; which schedule being as planned by the contractor and approved by the engineer

in accordance with the total calendar days or working days bid for the construction of the grading or the total completed project. The contractor shall furnish, operate, and maintain such equipment as is necessary to control uniform layers, section, and smoothness of grade for compaction and drainage.

(b) *Compacting.* The compacting equipment shall be of such design, weight and quantity to obtain the required density in accordance with the grading schedule.

1. **TAMPING ROLLER.**—The tamping roller shall consist of one or more units. Each unit shall consist of a watertight cylindrical drum not less than forty-eight (48) inches in length and shall be surmounted by metal studs with tamping feet projecting not less than seven (7) inches from the surface of the drum and spaced not less than six (6) inches nor more than ten (10) inches measured diagonally from center to center. The area of each tamper foot shall be not less than four (4) square inches nor more than twelve (12) square inches. Each unit shall be provided with a suitable tamper foot-cleaning device. Where more than one rolling unit is used, the rolling units shall be pivoted on the main frame in a manner which will permit the rolling units to adapt themselves to uneven ground surfaces and to rotate independently. When empty the roller shall weigh at least 120 pounds per square inch of area of tamping feet in contact with the ground. The maximum weight shall be such that the required densities are obtained. The roller and the operating tractor shall meet the approval of the engineer.

2. **PNEUMATIC ROLLER.**—The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

3. **SMOOTH ROLLER.**—The smooth self-propelled or power roller shall weigh at least ten (10) tons and may be of the tandem or three-wheel type. The wheels of the roller shall be equipped with adjustable scrapers. The roller shall be maintained in good condition and operated by an experienced rollerman.

4. **OTHER EQUIPMENT.**—Other equipment may be used for compacting and consolidating the embankments, subgrades, and other areas, upon approval of the engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

(c) *Watering.* Tank wagons, tank trucks, or distributors equipped with a suitable sprinkling device shall be used for watering. Satisfactory equipment shall be maintained on the project at all times when embankment construction is in progress.

152-2.9 PREPARATION AND PROTECTION OF THE TOP OF THE SUBGRADE. On areas to be paved, the six (6) inch depth in cut areas and the top nine (9) inches of embankment shall be compacted to the density specified and the surface when completed shall be true to the lines, grades, and cross section shown on the plans and/or as directed by the engineer. After all drains, structures, ducts, and other underground appurtenances along the edges or under the pavement have been completed, backfilled and compacted, the top portion of the subgrade shall be shaped correctly and brought to a firm, unyielding layer of not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. The rolling of the entire area shall be done with an approved power roller weighing not less than ten (10) tons or other approved type of roller. Any irregularities or depressions that develop under rolling shall be corrected by loosening the material at these places and adding, removing, or replacing material until the surface is smooth and uniform. Any portion of the area which is not accessible to a roller shall be compacted to the required density by approved mechanical tampers. The material shall be sprinkled with water during rolling or tamping when directed by the engineer.

All soft and yielding material and material which will not compact readily when rolled or tamped shall be removed as directed by the engineer and replaced with suitable material. After grading operations are complete, all loose stones larger than two (2) inches in their greatest dimension shall be removed from the surface of all proposed graded paving areas and disposed of as directed by the engineer.

At all times the top of the subgrade shall be kept in such condition that it will drain readily and effectively. In handling materials, tools, and equipment the contractor shall protect the subgrade from damage by laying planks thereon when directed and shall take such other precautions as may be deemed necessary. In no case will vehicles be allowed to travel in a single track. If ruts are formed, the subgrade shall be reshaped and rolled. Storage or stockpiling of materials on the top of the subgrade will not be permitted. Until the subgrade has been checked and approved, no subbase, base, or surface course or pavement shall be laid thereon.

152-2.10 HAUL. No payment will be made separately or directly for haul on any part of the work. All haul will be considered a necessary and incidental part of the work and the cost thereof shall be considered by the contractor and included in the contract unit price for the pay items of work involved.

152-2.11 TOLERANCES. In those areas upon which a subbase or base course is to be placed, the top of the subgrade shall be of such smoothness that when tested with a sixteen (16) foot straightedge it shall not show any deviation in excess of one-half ($\frac{1}{2}$) inch or shall not be more than five-hundredths (0.05) of a foot from true grade as established by grade hubs or pins. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing materials, reshaping, and recompacting by sprinkling and rolling.

On landing strips, intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than one-tenth (0.10) of a foot from true grade as established by grade hubs. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.

152-2.12 TOPSOIL. When topsoil is specified or required, as shown on the plans or under Item T-905 Topsoiling, topsoil shall be salvaged from stripping or other grading operations. The topsoil shall meet the requirements of Item T-905, or the approval of the engineer. If at the time of excavation or stripping the topsoil cannot be placed in its proper and final section of finished construction, the material shall be stockpiled at approved locations. Stockpiles shall not be placed within fifty (50) feet of pavement areas, and shall not be placed on areas which subsequently will require any excavation or embankment.

Upon completion of grading operations as herein specified, topsoil shall be handled and placed as directed or as required in Item T-905. The engineer shall set grade stakes in such manner for grading operations in both cut and fill so that the topsoil as placed will be at the finished plan elevation.

No direct payment will be made for topsoil as such under Item P-152. The quantity removed and placed or stockpiled will be paid for at the contract unit price per cubic yard for "Unclassified Excavation" or for "Common Excavation" when the latter classification is provided for in the proposal. When topsoil is paid for under Item P-152 as excavation, no payment shall be made for the same work under Item T-905.

In case stockpiling of topsoil and later rehandling of such material is directed by the engineer in order to produce the specified soil structure, the material so rehandled will be paid for at the contract unit price per cubic yard for "Unclassified Excavation" or "Common Excavation" when the latter classification is provided for in the proposal.

METHOD OF MEASUREMENT

152-3.1 The yardage to be paid for shall be the number of cubic yards measured in its original position, and pay quantities shall be computed to the neat lines staked, by the method of average end areas of materials acceptably excavated and stripped as herein specified.

152-3.2 Stockpiled material to be paid for shall be the number of cubic yards measured by cross-sectioning the ground surface prior to the placing of the material, and later re-cross-sectioning as soon as material has been stockpiled, and pay quantities shall be computed by the method of average end areas.

152-3.3 Borrow material to be paid for shall be the number of cubic yards measured in its original position in excavation, and pay quantities shall be computed by the method of average end areas. Borrow shall be classified as "Unclassified Excavation" or as "Com-

mon Excavation" if the latter classification is included in the proposal, or as "Borrow" when this classification is included in the proposal.

BASIS OF PAYMENT

152-4.1 UNCLASSIFIED EXCAVATION. This item will be paid for at the contract unit price per cubic yard for "Unclassified Excavation," which price and payment shall be full compensation for the removal and satisfactory disposal of all excavation regardless of material encountered, necessary in the preparation, construction, and completion of the project; for the removal of stockpiles; for formation, watering, and compaction of embankments; for preparation and completion of the top portion of the subgrade; for final dressing of the surfaces and slopes in accordance with the plans; and for furnishing all labor, equipment, tools, and incidentals necessary to complete this item.

152-4.2 COMMON EXCAVATION. This item will be paid for at the contract unit price per cubic yard for "Common Excavation," which price and payment shall be full compensation for the removal and satisfactory disposal of all excavation not included in "Solid Rock Excavation," necessary in the preparation, construction, and completion of the project; for the removal of stockpiles; for formation, watering, and compaction of embankments; for preparation and completion of the top portion of the subgrade; for final dressing of the surfaces and slopes in accordance with the plans; and for furnishing all labor, equipment, tools, and incidentals necessary to complete this item.

152-4.3 SOLID ROCK EXCAVATION. This item will be paid for at the contract unit price per cubic yard for "Solid Rock Excavation," which price and payment shall be full compensation for the removal and satisfactory disposal of boulders, detached rock, and of all rock in ledges or masses, necessary in the preparation, construction, and completion of the project; for incorporation of boulders or rock in embankments and on fill slopes; for final dressing of the surfaces and slopes in accordance with the plans; and for furnishing all labor, equipment, tools, and incidentals necessary to complete this item.

152-4.4 BORROW EXCAVATION. This item will be paid for at the contract unit price per cubic yard for "Borrow Excavation," which price and payment shall be full compensation for the furnishing and placing of the material; for formation, watering, and compaction of embankments; for preparation and completion of the top portion of the subgrade; for final dressing of the surfaces and slopes in accordance with the plans; and for furnishing all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

- Item P-152-4.1 Unclassified Excavation—per cubic yard.
- Item P-152-4.2 Common Excavation—per cubic yard.
- Item P-152-4.3 Solid Rock Excavation—per cubic yard.
- Item P-152-4.4 Borrow Excavation—per cubic yard.

ITEM P-153 WATERING

DESCRIPTION

153-1.1 This item shall consist of furnishing and applying water required in the compaction of embankments, subgrades, subbases, base courses, and for other purposes in accordance with the requirements of these specifications, or as directed by the engineer.

CONSTRUCTION METHODS

153-2.1 Water, when required, shall be applied at the locations, in the amounts and during the hours, including nights, as directed by the engineer. An adequate water supply shall be provided by the contractor. The equipment used for watering shall be of ample capacity and of such design as to assure uniform application of water in the amounts directed by the engineer.

METHOD OF MEASUREMENT

153-3.1 The units of watering to be paid for (subject to 4.1) shall be the number of 1,000-gallon units of water, measured in the vehicle at the point of delivery on the airport, and used as ordered.

BASIS OF PAYMENT

153-4.1 When the bid schedule contains an estimated quantity for any one of the items below, the units measured as provided above shall be paid for at the contract unit price per 1,000-gallon unit for watering of embankment, watering of subgrade, watering of subbase, or watering of base course, as the case may be, which price and payment shall be full compensation for furnishing, hauling, and placing; and for all labor, equipment, tools, and incidentals necessary to complete the item, including the furnishing of water plants if necessary.

When the bid schedule does not contain an estimated quantity for any one of the above items, the performance of these items shall be considered as a subsidiary obligation of the contractor covered under pay items involved in the contract and no allowance shall be made for providing or maintaining a water plant.

Payment will be made under:

Item P-153-4.1 Watering—per 1,000-gallon unit.

ITEM P-154 SUBBASE COURSE

DESCRIPTION

154-1.1 This item shall consist of a subbase course composed of granular materials constructed on a prepared subgrade or underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

MATERIALS

154-2.1 MATERIALS. The subbase material shall consist of hard durable particles or fragments of granular aggregates mixed or blended with fine sand, clay, stone dust, or other similar binding or filler materials, produced from approved sources to provide a uniform mixture complying with the requirements of these specifications as to gradation, soil constants, and capability of being compacted into a dense and stable subbase. The material shall be free from vegetable matter, lumps or excessive amount of clay and other objectionable or foreign substances. Pit-run material may be used, provided the material meets the requirements specified.

TYPE A SUBBASE

(10-inch frost penetration or greater)

Sieve designation	Percent passing by weight
3-inch.....	100
No. 40.....	Not more than 70

The material passing the No. 10 mesh sieve shall meet the following requirements:

Sieve designation	Percent passing by weight
No. 10.....	100
No. 40.....	25-70
No. 200.....	0-15

Liquid Limit, not more than 25.

Plasticity Index, not more than 6.

If more than forty-five (45) percent of the entire sample is retained on the No. 10 mesh sieve, the amount of material passing the No. 200 mesh sieve may be increased to twenty-five (25) percent if Liquid Limit and Plasticity Index are not increased.

TYPE B SUBBASE

(Less than 10-inch frost penetration)

Sieve designation	Percent passing by weight
3-inch.....	100
No. 40.....	Not more than 70

The material passing the No. 10 mesh sieve shall meet the following requirements:

Sieve designation	Percent passing by weight
No. 10.....	100
No. 40.....	25-70
No. 200.....	0-35

Liquid Limit, not more than 35.
Plasticity Index, not more than 9.

If more than forty-five (45) percent of the entire sample is retained on the No. 10 mesh sieve, the amount of material passing the No. 200 mesh sieve may be increased to forty-five (45) percent if Liquid Limit and Plasticity Index are not increased.

CONSTRUCTION METHODS

154-3.1 GENERAL. The subbase course shall be placed where designated on the plans or as directed by the engineer. The material shall be shaped and thoroughly compacted within the tolerances specified.

The granular subbases, which due to grain sizes or shape, are not sufficiently stable to support without movement the construction equipment, shall be mechanically stabilized to a minimum depth of three (3) or four (4) inches of the top layer as directed by the engineer. The mechanical stabilization shall include the addition principally of a fine grained medium to bind the particles of the subbase material sufficiently to furnish a bearing strength so that the course will not deform under the traffic of the construction equipment. The addition of the binding medium to the subbase material shall not increase the soil constants of that material above the limits as shown.

154-3.2 OPERATION IN PITS. All work involved in clearing and stripping pits and handling unsuitable material encountered shall

be performed by the contractor at his own expense. The subbase material shall be obtained from pits or sources that have been approved. The material in the pits shall be excavated and handled in a manner that a uniform and satisfactory product shall be secured.

154-3.3 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The processing equipment shall be designed, constructed, operated, and of such capacity so as to thoroughly mix all materials and water in the proportions as directed to produce a subbase course of the gradation and consistency required.

154-3.4 PREPARING UNDERLYING COURSE. Before any subbase material is placed, the underlying course shall be prepared and conditioned as specified. The course shall be checked and accepted by the engineer before placing and spreading operations are started.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the subgrade and to insure proper drainage, the spreading of the subbase shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

154-3.5 MATERIALS ACCEPTABLE IN EXISTING CONDITION. When the entire subbase material is secured in a uniform and satisfactory condition and contains approximately the required moisture, such approved material may be handled directly to the spreading equipment for placing. The material may be obtained from gravel pits, stock piles, or be produced from a crushing and screening plant with the proper blending. The materials from these sources shall meet the requirements for gradation, quality, and consistency. It is the intent of this section of the specifications of securing materials that will not require further mixing. The moisture content of the material shall be approximately the required moisture content to obtain maximum density. Any minor deficiency or excess of moisture may be corrected by surface sprinkling or by aeration. In such instances some mixing or manipulation may be required immediately preceding the rolling to obtain the required moisture content. The final operation shall be blading or dragging, if necessary, to obtain a smooth uniform surface true to line and grade.

154-3.6 PLANT MIXING. When materials from several sources are to be blended and mixed or when required in the proposal, the subbase material shall be processed in a central mixing plant or in

a travel mixing plant. The subbase material, together with any blended material, shall be thoroughly mixed with the required amount of water. After the mixing is complete the material shall be transported to and spread on the underlying course without undue loss of the moisture content.

154-3.7 MIXED IN-PLACE. When materials from different sources are to be proportioned and mixed or blended in place, the different layers shall be spread and placed in the following manner, the relative proportions of the components of the mixture being as designated by the engineer.

The subbase material shall be deposited and spread evenly to a uniform thickness and width. Then the binder, filler, or other material shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the engineer may direct to obtain the required subbase mixture.

When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary tillers, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniform throughout. Areas of segregated material shall be corrected by the addition of binder or filler material and by thorough remixing. Water in the amount and as directed by the engineer shall be uniformly applied prior to and during the mixing operations, if necessary, to maintain the material at its required moisture content. When the mixing and blending has been completed, the material shall be spread in a uniform layer which, when compacted, will meet the requirements of thickness and typical cross section.

154-3.8 GENERAL METHODS FOR PLACING. The subbase course shall be constructed in layers. Any layer shall be not less than three (3) inches nor more than eight (8) inches of compacted thickness. The material as spread shall be of uniform gradation with no pockets of fine or coarse materials. The subbase, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within this limit. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, shoulder, or foreign material in the subbase course mixture.

154-3.9 FINISHING AND COMPACTING. After spreading or mixing the subbase, material shall be thoroughly compacted by rolling and sprinkling when necessary. The initial rolling of the course shall be done with tamping rollers when course is five (5) inches or more in thickness and when the roller does not cause segregation. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding track by at least twelve (12) inches. The rolling shall continue until the material is thoroughly set and stable. Rolling shall continue until the subbase material has been compacted to not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, and uniformly compacted subbase. For final rolling the ten-ton three-wheel roller shall be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wave-like motion in the subbase. When the rolling develops irregularities that exceed one-half ($\frac{1}{2}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course and again rolled as required above.

Along places inaccessible to rollers, the subbase material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer. Water shall not be added in such manner or quantity that free water will reach the underlying layer and cause it to become soft.

154-3.10 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompact, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than one-half ($\frac{1}{2}$) inch from the sixteen (16) foot straight-edge applied to the surface parallel to the center line and at right angles.

154-3.11 THICKNESS. The thickness of the completed subbase course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 500 square yards. When the deficiency in thickness is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying, adding satisfactory mixture, rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The contractor shall replace at his expense the subbase material where borings are taken for test purposes.

154-3.12 PROTECTION. Work on subbase course shall not be prosecuted during freezing temperature nor when the subgrade is wet. When the subbase material contains frozen material or the underlying course is frozen, the construction shall be stopped.

154-3.13 MAINTENANCE. Following the final shaping of the material, the subbase shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the subbase meets all requirements and is acceptable for the construction of the next course.

METHOD OF MEASUREMENT

154-4.1 The yardage of subbase course to be paid for shall be the number of cubic yards of subbase course material placed, compacted, and accepted in the completed course. The quantity of subbase course material shall be measured in final position based upon depth tests or cores taken as directed by the engineer or at the rate of one depth test for each 500 square yards of subbase course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as the specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment. Subbase materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

154-5.1 The yardage of subbase course measured as provided above shall be paid for at the contract unit price bid per cubic yard for subbase course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the materials; for mixing, blading, sprinkling, shaping, and compacting; for reconditioning the underlying course; for reconstruction of irregular surface, or deficient thickness, and for maintenance; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit moves; for clearing, stripping, drainage, and clean-up of pits; for handling and disposal of unsuitable materials encountered in pit operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-154-5.1 Subbase Course—per cubic yard.

FENCES

ITEM P-160 WIRE FENCE WITH WOOD POSTS (Class "A" and "B" Fences)

DESCRIPTION

160-1.1 This item covers the requirements for furnishing materials and constructing new wire fences and gates with wood posts in accordance with the details included herein and as shown on the plans. The class of fence to be erected shall be either Class "A," woven wire fencing surmounted by two (2) strands of barbed wire, or Class "B," four (4) strands of barbed wire, as indicated on the plans and in the bid proposal.

MATERIALS

160-2.1 WIRE. (a) *Woven Wire (Zinc-Coated).* The woven wire fencing shall be 7-bar, 26-inch field fence with top and bottom wires No. 10 ASW gauge, and filler and stay wires, No. 12½ ASW gauge. Stay wires shall be spaced six (6) inches apart. All wires shall be smooth galvanized steel wire, conforming to Federal Specification RR-F-221, Type B. All wires shall be two dip and spaced as shown on the plans.

(b) *Barbed Wire (Zinc-Coated).* Barbed wire shall be two-strand twisted No. 12½ ASW gauge galvanized steel wire with either two-point or four-point barbs of No. 14 ASW gauge galvanized steel wire. All wires shall conform to Federal Specification RR-F-221, Type A. All wires shall be two dip and spaced as shown on the plans. Two-point barbs shall be spaced five (5) inches apart, and four-point barbs shall be spaced six (6) inches apart.

(c) *Bracing Wire (Zinc-Coated).* Wire used for cable for bracing shall be No. 9, smooth galvanized soft wire.

160-2.2 GATES. (a) Gates shall be constructed of galvanized steel tubing as shown on the plans and shall be of the size as specified. Fabric shall be heavily galvanized and shall be of the size shown on the plans. All wire shall be tied in firmly and securely to the gate frame.

(b) *Gate Hardware.* Heavily galvanized hinges and latches for wood posts shall be furnished with each gate. Either a bolt or lag screw hinge shall be used, and either a wing or butterfly latch shall be furnished.

160-2.3 POSTS (a) Species. All posts shall be one of the following species of wood, unless otherwise noted in the proposal:

Group I

Cedar
Chestnut
Cypress, Southern
Locust, Black
Osage-orange
Redwood
Yew, Pacific
Honey Locust
Oak, White
Mulberry
Live Oak

Group II

Douglas Fir
Gum, Red
Larch, Western
Pine, Southern Yellow
Pine, Lodgepole
Tamarack
Ash
Maple, Sugar
Oak, Red
Spruce

Posts of Group I may be used untreated provided at least seventy-five (75) percent of the wood is heartwood. Posts of less than seventy-five (75) percent heartwood of Group I shall be given a preservative treatment for the part of the post that will have contact with the ground and for a distance of at least six (6) inches above the ground line in accordance with the method specified under subparagraph (e)-1, below. Posts of Group II shall be given a preservative treatment in accordance with the method specified under subparagraph (e)-2, below.

(b) *Quality.* Posts shall be peeled, sound, straight-grained, free from decay, cracks, and splits; shakes shall not be in excess of one-quarter ($\frac{1}{4}$) inch wide and three (3) feet long. Checks (lengthwise separations of the wood in a generally radial direction) are permitted, provided they are not injurious.

(c) *Dimensions.* All posts shall be of the length shown on the plans. Posts shall have the minimum top diameters shown on the plans or as specified. Sawed and split posts are acceptable in lieu of round posts provided their dimensions are such that round posts of required diameter could be turned therefrom.

(d) *Manufacture.* Outer bark shall be completely removed from all posts. Inner bark shall be removed from all post surfaces to be treated, except inner bark may remain in depressions. Outer bark in all such depressions shall be removed. The amount of wood shaved off in the removal of inner bark shall be held to a minimum.

(e) *Treatment—1. BUTT TREATMENT.* All timber shall be thoroughly seasoned and dry (twenty-two (22) percent maximum moisture content) before applying preservative treatment. The treatment shall be by a process at least equal to a hot and cold bath process. The hot bath temperature shall be from 200° F. to 230° F. for a duration of forty-five (45) minutes, and the cold bath temperature not over 120° F. for a duration of forty-five (45) minutes. The preservative shall be either coal-gas tar or coke-oven tar creosote conforming to American Wood Preservers Association Specification No. 4 for Grade 1 creosote; or a five (5) percent minimum, by weight, pentachlorophenol petroleum

solution made by either mixing a liquid concentrate of pentachlorophenol in fuel oil or kerosene, or by dissolving pentachlorophenol crystals of technical purity in suitable fuel oil solvents.

2. **FULL LENGTH TREATMENT.** Posts shall be conditioned by air seasoning, by steaming, or by heating in oil in such a manner as will not cause injurious checking, splitting, or warping before treating. The treatment shall be by an empty-cell process with a final retention of six (6) pounds preservative per cubic foot of wood in charge in accordance with the appropriate A. W. P. A. Specification. The preservative shall be either coal-gas tar or coke-oven tar creosote conforming to A. W. P. A. Specification No. 4 for Grade 1 creosote; or a five (5) percent minimum by weight, pentachlorophenol petroleum solution. The pentachlorophenol solution shall be made by mixing a liquid concentrate of pentachlorophenol in fuel oil or kerosene, or by dissolving pentachlorophenol crystals of technical purity in suitable fuel oil solvents.

Corner, anchor, and gate posts shall have all required gains and notches for braces painted with creosote after cutting.

160-2.4 BRACES. Cleats, gate stops, and braces shall be of the size shown on the plans. They shall be of the same species and quality specified for the posts or approved by the engineer and shall be free from knots larger than one-third ($\frac{1}{3}$) the width of the piece. Gate stops shall be made of posts of suitable length. Braces may be made of posts of suitable length or of sawed lumber. All cleats, gate stops, and any braces in contact with the ground and for a distance of at least six (6) inches above the ground shall be treated by the hot and cold bath process, specified herein for posts. The wire used in cable for bracing shall conform to section 2.1 (c), previously mentioned.

160-2.5 STAPLES. The staples shall be No. 9 galvanized steel wire, one (1) inch long for hardwood posts and one and one-half ($1\frac{1}{2}$) inches long for use in softwood posts.

CONSTRUCTION METHODS

160-3.1 GENERAL. The fence shall be constructed in accordance with the details on the plans and as specified herein, with new materials, and all work shall be performed in a workmanlike manner, satisfactory to the engineer. Prior to the beginning of the work, or upon the request of the contractor, the engineer will locate the position of the work by establishing and marking the property line or fence line. At locations of small natural or drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the contractor, when directed, shall span the opening below the fence with barbed wire fastened to posts of extra length as required. The new fence shall be permanently tied to the terminals of existing fences whenever required by the engineer. The finished fence shall be plumb, taut, true to line and ground contour, and com-

plete in every detail. When directed, the contractor will be required to stake down the woven wire fence at several points between posts.

When directed, in order to keep stock on adjoining property inclosed at all times, the contractor shall arrange the work so that construction of the new fence will immediately follow the removal of existing fences. The length of unfenced section at any time shall not exceed three hundred (300) feet, or such length that the stock can be kept in the proper field. The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the unremoved existing fence. Any openings in the fence shall not be unguarded when stock is using the adjoining property.

160-3.2 CLEARING FENCE LINE. The site of fence shall be sufficiently cleared of obstructions and surface irregularities shall be graded so that the fence will conform to the general contour of the ground. The fence line shall be cleared to a minimum width of two (2) feet on each side of the center line of the fence. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. Stumps within the cleared area of the fence line shall be grubbed or excavated. The bottom of the fence shall be placed a uniform distance above ground as specified in the plans. When shown on the plans, or as directed by the engineer, the existing fences which coincide with, or are in a position to interfere with the new fence location, shall be removed by the contractor as part of the construction work, unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other material acceptable to the engineer, and shall be compacted properly with tampers.

The work shall include the handling and disposal of all material cleared, of excess excavation and the removal of spoil material regardless of the type, character, composition or condition of such material encountered.

160-3.3 SETTING POSTS. Posts shall be set with large ends down, plumb, and in good line on the side on which the wire is to be fastened. Posts shall be set full depth and shall not be cut off to eliminate rock or other excavation. Where rock is encountered, it shall be removed, even if blasting is necessary to provide full-depth and size holes. The bottoms of all posts shall be cut off square. The diameter of the holes shall be at least six (6) inches larger than the diameter of the posts. When cleats are used on posts the holes shall be dug large enough to accommodate them. After posts are placed and lined, the holes shall be backfilled with suitable material which shall be properly compacted by the use of tampers. The posts adjacent to end, corner, anchor, and gate posts shall be set and braced with braces and wire, as shown on the plans. No extra compensation will be made for rock excavation. Rock excavation shall not be grounds for extension of time.

160-3.4 ANCHORING. Corner, end, gate, and adjacent intermediate posts shall be anchored by gaining and spiking cleats to the

sides of the posts, as indicated on the plans. No cleats will be required on other intermediate posts or on anchor posts.

160-3.5 BRACING. End, corner, anchor, and gate posts shall be braced by using a post of sufficient length or a piece of sawed lumber of the proper size, together with a wire cable. The wooden brace shall be gained and securely spiked into the end, corner, anchor, or gate posts and into the next intermediate posts about six (6) inches from the top of the respective posts. A cable made of a double strand of galvanized soft wire shall be looped around the end, corner, anchor, or gate post near the ground and around the next intermediate post about twelve (12) inches from the top. After the cable has been stapled in this position, it shall be twisted until tight. The staples used to hold the cable shall be not less than one and one-half ($1\frac{1}{2}$) inches long. The tool used for twisting the cable shall be left in place to permit later adjustment of bracing if found necessary. Anchor posts shall be set at approximately 500-foot intervals and braced to the adjacent posts. Posts shall be braced before the wire fencing is placed.

160-3.6 INSTALLING WIRE. The wires shall be placed on the side of the posts away from the airport, or as directed. The wire fence shall be placed on the posts at the height indicated on the plans. Longitudinal wires shall be installed parallel and drawn uniformly taut. The vertical stay wires of the woven wire fencing shall be straight and vertical. At end and gate posts the woven wire and barbed wire shall be wrapped once around the post; each longitudinal wire shall be stapled at least three (3) times and the ends of these wires shall be tied with a snug, tight, twist. Each longitudinal wire shall be stapled to each intermediate post with one (1) steel wire staple; at the corner and anchor posts, two (2) or more staples shall be used. The top strand of barbed wire of all fences shall be stapled with two (2) staples in each post. All staples shall be set diagonally with the grain of the wood and driven up tight. After the fence has been erected, the tops of the wood posts shall be sawed off with a one to three pitch. The bottom wire of the woven wire fencing shall clear the ground by not more than four (4) inches or less than one (1) inch at any place.

160-3.7 SPLICING WIRE. Wire splices in longitudinal wires will be permitted if made with an approved galvanized bolt clamp splice, or a wire splice made as follows: The end of the wires shall be carried three (3) inches past the splice tool and wrapped around the other wires away from the tool for at least six (6) turns in opposite direction, similar to the standard Western Union splice for iron wire. After the tool is removed, the space occupied by it shall be closed by pulling the ends together. The unused ends of the wires shall be cut close so as to make a neat, workmanlike, job. Woven wire may be spliced only at posts.

160-3.8 INSTALLING GATES. The gates shall be hung on gate fittings, as shown on the plans. Fittings on the gate posts shall be clamped, screwed, or bolted to prevent slipping. Gates shall be so erected as to swing in the direction indicated and shall be provided

with gate stops, as specified, or as shown on the plans. Gates shall be erected at suitable places, as directed by the engineer, or as shown on the plans.

160-3.9 EXISTING FENCE CONNECTIONS. Wherever the new fence joins an existing fence, either at a corner or the intersection of straight fence lines, a corner or anchor post shall be set at the junction and braced and anchored the same as herein described for corner posts and shown on the plans.

If the connection is made at other than the corner of the new fence, the last span of the old fence shall contain a brace span.

160-3.10 CLEANING UP. The contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., belonging to him or used under his direction during construction.

METHOD OF MEASUREMENT

160-4.1 Fences, Class "A" (Wood Posts), or Class "B" (Wood Posts), shall be measured in place from outside to outside of end posts or corner posts and shall be the length of fence actually constructed, except the space occupied by the gates.

Driveway gates and walkway gates shall be measured in units for each gate installed and accepted.

BASIS OF PAYMENT

160-5.1 Fences, Class "A" (Wood Posts), or Class "B" (Wood Posts), shall be paid for at the contract unit price per linear foot complete in place, which price and payment shall constitute full compensation for clearing the fence line; for furnishing, handling, erecting and placing all materials; and for furnishing all labor, equipment, tools and incidentals necessary to complete the work.

Gates shall be paid for at the contract unit price each per driveway gate and per walkway gate complete in place, which price and payment shall constitute full compensation for furnishing, handling, erecting all materials complete with fittings; and for furnishing all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

Item P-160-5.1 Fence, Class "A"—per linear foot.

Item P-160-5.1 Fence, Class "B"—per linear foot.

Item P-160-5.1 Driveway Gates—per each.

Item P-160-5.1 Walkway Gates—per each.

ITEM P-161 WIRE FENCE WITH STEEL POSTS (Class "C" and "D" Fences)

DESCRIPTION

161-1.1 This item covers the requirements for furnishing materials and constructing new wire fences and gates with steel posts in accordance with the details included herein and as shown on the plans. The class of fence to be erected shall be either Class "C," woven wire fencing surmounted by two (2) strands of barbed wire, or Class "D," four (4) strands of barbed wire, as indicated on the plans and in the bid proposal.

MATERIALS

161-2.1 WIRE. (a) *Woven Wire (Zinc-Coated)*. The woven wire fencing shall be 7-bar, 26-inch field fence with top and bottom wires No. 10 ASW gauge, and filler and stay wires No. 12½ ASW gauge. Stay wires shall be spaced six (6) inches apart. All wires shall be smooth galvanized-steel wire conforming to Federal Specification RR-F-221, Type B. All wires shall be two-dip and spaced as shown on the plans.

(b) *Barbed Wire (Zinc-Coated)*. Barbed wire shall be two-strand twisted No. 12½ ASW gauge galvanized steel wire with either two-point or four-point barbs of No. 14 ASW gauge galvanized steel wire conforming to Federal Specification RR-F-221, Type A. All wires shall be two-dip and spaced as shown on the plans. Two-point barbs shall be spaced five (5) inches apart and four-point barbs shall be spaced six (6) inches apart.

(c) *Bracing Wire (Zinc-Coated)*. Wire used for cable for bracing shall be No. 9, smooth galvanized soft wire.

161-2.2 GATES. (a) Gates shall be constructed of galvanized steel tubing as shown on the plans and shall be of the size as specified. Fabric shall be heavily galvanized and shall be of the size shown on the plans. All wires shall be tied in firmly and securely to the gate frame.

(b) *Gate Hardware*. Heavily galvanized hinges and latches for steel posts shall be furnished with each gate. Hinges shall be similar or equal to Hinge Collar No. K-3934, manufactured by the American Steel and Wire Company. A spring latch or a pig-ear latch similar or equal to No. K-3964A or No. K-3954, manufactured by the American Steel and Wire Company, shall be installed on the gate.

161-2.3 POSTS. Corner, brace, and gate posts shall be $2\frac{1}{2}$ " x $2\frac{1}{2}$ " x $\frac{1}{4}$ " minimum galvanized steel angle 7 feet long, as shown on the plans. Line posts shall be $1\frac{1}{4}$ " x $1\frac{1}{4}$ " x $\frac{1}{8}$ " minimum galvanized steel angle 7 feet long, as shown on the plans. Posts shall be of rail steel, A. S. T. M. Designation A-16, or hard grade billet steel, A. S. T. M. Designation A-15. Other sections of steel or metal posts may be used when approved by the engineer.

161-2.4 RAILS. Rails shall be 2" x 2" x $\frac{3}{16}$ " minimum galvanized steel angle 9' $11\frac{1}{4}$ " long, as shown on the plans. Rails shall be of rail steel, A. S. T. M. Designation A-16; hard grade billet steel, A. S. T. M. Designation A-15; or structural steel, A. S. T. M. Designation A-7.

161-2.5 BRACES. Braces shall be 2" x 2" x $\frac{3}{16}$ " minimum galvanized steel angle 10' $8\frac{3}{8}$ " long, as shown on the plans. Braces shall be of rail steel, A. S. T. M. Designation A-16; hard grade billet steel, A. S. T. M. Designation A-15; or structural steel, A. S. T. M. Designation A-7.

161-2.6 FITTINGS AND FASTENINGS. Fittings and fastenings shall be hot-dip galvanized steel as shown on the plans.

161-2.7 CONCRETE. Concrete shall be 1:2 $\frac{1}{2}$:5 mix of approved materials, placed in accordance with Item P-610.

CONSTRUCTION METHODS

161-3.1 GENERAL. The fence shall be constructed in accordance with the details on the plans and as specified herein, with new materials, and all work shall be performed in a workmanlike manner satisfactory to the engineer. Prior to the beginning of the work, or upon the request of the contractor, the engineer will locate the position of the work by establishing and marking the property line or fence line. At locations of small natural or drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the contractor, when directed, shall span the opening below the fence with barbed wire fastened to stakes of such length as required. The new fence shall be permanently tied to the terminals of existing fences whenever required by the engineer. The finished fence shall be plumb, taut, true to line and ground contour, and complete in every detail. When directed, the contractor will be required to stake down the woven wire fence at several points between posts.

When directed, in order to keep stock on adjoining property inclosed at all times, the contractor shall arrange the work so that construction of the new fence will immediately follow the removal of existing fences. The length of unfenced section at any time shall not exceed three hundred (300) feet, or such length that the stock can be kept in the proper field. The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the unremoved existing fence. Any openings

in the fence shall not be left unguarded when stock is using the adjoining property.

161-3.2 CLEARING FENCE LINE. The site of the fence shall be sufficiently cleared of obstructions and surface irregularities shall be graded so that the fence will conform to the general contour of the ground. The fence line shall be cleared to a minimum width of two (2) feet on each side of the center line of the fence. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. Stumps within the cleared area of the fence line shall be grubbed or excavated. The bottom of the fence shall be placed a uniform distance above ground, as specified in the plans. When shown on the plans, or as directed by the engineer, the existing fences which coincide with or are in a position to interfere with the new fence location, shall be removed by the contractor as a part of the construction work, unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other material acceptable to the engineer, and shall be compacted properly with tampers.

The work shall include the handling and disposal of all material cleared, excavated or removed, regardless of the type, character, composition or condition of such material encountered.

161-3.3 INSTALLING POSTS. All posts shall be spaced as shown on the plans. Corner, brace, anchor, end, and gate posts shall be set in concrete bases as shown on the plans. The top of the base shall be slightly above the ground surface, trowel finished, and sloped to drain. Holes of full depth and size for the concrete bases for posts shall be provided even if blasting of rock or other obstructions is necessary. All line posts may be either driven, or set in dug holes, to a penetration of three (3) feet. All post setting shall be done carefully and to true alignment. Should dirt be removed for placing posts, anchor bars, flanges, etc., it shall be replaced, tamped, and levelled. When posts are driven, care shall be exercised to prevent marring or buckling of the posts. Damaged posts shall be replaced at the contractor's expense. No extra compensation will be made for rock excavation. Rock excavation shall not be grounds for extension of time.

161-3.4 BRACING. All corner, anchor, end, and gate posts shall be braced as shown on the plans. Anchor posts shall be set at approximately 500-foot intervals and braced to the adjacent posts.

161-3.5 INSTALLING WIRE. All barbed wire and woven wire shall be placed on the side of the posts away from the airport, or as directed, at the height indicated on the plans. The woven wire shall be carefully stretched and hung without sag and with true alignment, care being taken not to stretch the wire so tightly that it will break in cold weather or pull up corner and brace posts. All horizontal wires shall be fastened securely to each post by fasteners or clips designed for use with the posts furnished. The woven wire shall be wrapped around end, corner, and gate posts, and the ends of all

horizontal wires shall be tied with snug, tight twists. The wire shall be secured to prevent slipping up and down the post. Barbed wire strands shall be stretched and each strand secured to each post to prevent slipping out of line or becoming loose. At end, corner, and gate posts the barbed wire shall be securely wrapped and anchored once about the post from outside and secured against slipping by tying the ends with snug, tight twists; provided, however, that on spans of less than one hundred (100) feet both ends of the span need not be wrapped around the posts. The bottom wire of the woven wire fencing shall clear the ground by not more than four (4) inches or less than one (1) inch at any place.

161-3.6 SPLICING WIRE. Splices in barbed and woven wire will be permitted if made with an approved galvanized bolt clamp splice, or a wire splice made as follows: The ends of each wire shall be carried three (3) inches past the splice tool and wrapped around the other wire for at least six (6) turns in opposite directions similar to the standard Western Union splice for iron wire. After the tool is removed, the space occupied by it shall be closed by pulling the ends together. The unused ends of the wire shall be cut close so as to make a neat, workmanlike job.

161-3.7 INSTALLING GATES. The gates shall be hung on gate fittings as shown on the plans. They shall be attached in such a manner that the gate cannot be lifted off the hinges. Gates shall be so erected as to swing in the direction indicated and shall be provided with gate stops as specified, or as shown on the plans. Gates shall be erected at suitable places, as directed by the engineer, or as shown on the plans.

161-3.8 EXISTING FENCE CONNECTIONS. Wherever the new fence joins an existing fence, either at a corner or the intersection of straight fence lines, a corner or anchor post shall be set at the junction and braced and anchored the same as herein described for corner posts and shown on the plans.

If the connection is made at other than the corner of the new fence the last span of the old fence shall contain a brace span.

161-3.9 CLEANING UP. The contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., belonging to him or used under his direction during construction.

METHOD OF MEASUREMENT

161-4.1 Fences, Class "C" (Steel Posts), and Class "D" (Steel Posts), shall be measured in place from outside to outside of end posts or corner posts and shall be the length of fence actually constructed, except the space occupied by the gates.

Driveway gates and walkway gates shall be measured in units for each gate installed and accepted.

BASIS OF PAYMENT

161-5.1 Fences, Class "C" (Steel Posts) and Class "D" (Steel Posts), shall be paid for at the contract unit price per linear foot complete in place, which price and payment shall constitute full compensation for clearing the fence line; for furnishing, handling, erecting, and placing all materials; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Gates shall be paid for at the contract unit price each per driveway gate and per walkway gate complete in place, which price and payment shall constitute full compensation for furnishing, handling, erecting all materials complete with fittings; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- Item P-161-5.1 Fence, Class "C"—per linear foot.
- Item P-161-5.1 Fence, Class "D"—per linear foot.
- Item P-161-5.1 Driveway Gates—per each.
- Item P-161-5.1 Walkway Gates—per each.

ITEM P-162 CHAIN-LINK FENCES

(Class "E")

DESCRIPTION

162-1.1 This item covers the requirements for furnishing materials and constructing new chain-link fences and gates in accordance with the details included herein and as shown on the plans. The class of fence to be erected shall be Class "E" chain-link fencing, as indicated on the plans and in the bid proposal.

The fence shall be the product of a manufacturer who has demonstrated by actual installations of a similar nature that its product is of the type required. The contractor shall include all supplementary parts necessary or required for a complete and satisfactory installation within the true meaning and intent of the drawings. All runs of the fence shall present the same general appearance and the product of one manufacturer only will be accepted, except for items which do not influence the appearance of the completed fence. No used, rerolled, or open-seam steel will be permitted in posts, gate frames, rails, or braces.

MATERIALS

162-2.1 FABRIC. (a) The chain-link fabric shall be No. 6 ASW gauge copper-steel wire woven in a two (2) inch mesh and shall be four (4) feet high. The fabric shall meet the requirements of A. S. T. M. Designation A-117. The fabric shall be heavily zinc-coated by the hot-dip process after weaving. The fabric shall have a knuckled selvage along the top rail. The fabric at the bottom of the fence shall have a twisted and barbed selvage; the barbing shall be done by cutting the wire on a bias, thus creating sharp points.

(b) *Tensile Strength Test.* Wire pickets of which this fabric is made shall stand a tensile strength test of 70,000 pounds per square inch, based on the cross-sectional area of the galvanized wire.

(c) *Galvanizing Test.* Chain-link fabric shall withstand twelve (12) one-minute immersions under the standard Preece Test. The test is to be made on a section of wire picket at least four (4) inches in length so as to include at least one bend and one straight side of the formed link.

162-2.2 POSTS. (a) *Line Posts.* Line posts shall be one of the following sections:

- (1) Pipe section, not less than 2 inches O. D.—2.72 pounds per linear foot.
- (2) H section, not less than 2.72 pounds per linear foot.
- (3) U section, not less than 2.65 pounds per linear foot.
- (4) I section, not less than 2.30 pounds per linear foot.

(b) *Terminal Posts.* Terminal posts (end, corner, pull, and brace posts) shall be one of the following sections:

- (1) Pipe section, not less than 2½ inches O. D.—3.65 pounds per linear foot.
- (2) Square tubing, not less than 2½ inches, 3.65 pounds per linear foot.

(c) *Gate Posts.* Gate posts (not over six (6) feet wide single or twelve (12) feet wide double gate opening) shall be one of the following sections:

- (1) Pipe section, not less than 3 inches O. D.—5.79 pounds per linear foot.
- (2) Square tubing, not less than 2½ inches, 6.5 pounds per linear foot.

Gate posts (over six (6) feet to thirteen (13) feet wide single, or twelve (12) feet to twenty-six (26) feet wide double gate opening) shall be one of the following sections:

- (1) Pipe section, not less than 4 inches O. D.—9.1 pounds per linear foot.
- (2) Square tubing, not less than 3 inches, 9.7 pounds per linear foot.

(d) The line, terminal (end, corner, pull, and brace posts), and gate posts shall be hot-dip galvanized copper-steel.

162-2.3 TOP RAILS. Top rails shall be hot-dip galvanized copper-steel sections of either pipe, not less than 1½ inches O. D. weighing not less than 2.72 pounds per linear foot, or an "H" section weighing not less than 2.72 pounds per linear foot, or an equivalent section of equal strength approved by the engineer. Top rail shall pass through the base of the line post tops and form a continuous brace from end to end of each run of fence. Couplings shall be outside sleeve type and at least seven (7) inches long; one coupling in every five shall contain a heavy spring to take up expansion and contraction of the top rail.

162-2.4 POST TOPS. All posts shall be fitted with heavy malleable iron or pressed steel tops. Bases of the post tops shall have flanges around the outside of the posts.

162-2.5 GATES. (a) *Frames.* Gate frames shall be hot-dip galvanized copper-steel pipe not less than 2 inches O. D. weighing

not less than 2.72 pounds per linear foot or an equivalent section of equal strength approved by the engineer. The gate frames shall be provided with $\frac{3}{8}$ -inch round hot-dip galvanized copper-steel rods for cross bracing, as shown on the plans.

(b) *Hinges.* Hinges shall be high grade, malleable iron of the ball and socket type which will permit the gate to swing back against fence. The lower hinges of the gates shall support the entire vertical load of the gates as well as provide for the resultant horizontal reaction.

(c) *Fabric.* The chain-link fabric for gates shall be the same as specified for the fence under section 2.1 (a), (b) and (c) mentioned above.

(d) *Miscellaneous Fittings.* The gates shall be fitted with approved latches and provision for padlocking. Latches, hasps, and bolts shall be accessible from the side or sides of the gates as shown on the plans or as directed by the engineer. Approved catches shall be provided for holding gates in an open position where directed.

(e) *Cane Bolts.* Cane bolts shall be as indicated on the plans. They shall be so set as to engage the sockets previously set in concrete to hold the gates in true alignment when closed and to hold them in position when opened to the full width of the openings. Leaves of double gates not equipped with cane bolts shall be provided with foot bolts of approved design to hold the gates in a closed position.

162-2.6 BRACES. Braces shall be hot-dip galvanized copper-steel sections of either pipe not less than $1\frac{5}{8}$ inches O. D.—2.72 pounds per linear foot; or an “H” section weighing not less than 2.72 pounds per linear foot or an equivalent section of equal strength approved by the engineer. The braces are to be spaced midway between the top rail and the ground, and are to extend from all terminal (end, corner, and pull) posts and gate posts to the brace posts. The braces shall be securely fastened to the posts by means of malleable iron or pressed steel clamps, then trussed from brace post back to terminal posts with $\frac{3}{8}$ -inch round, hot-dip galvanized copper-steel rod with a turnbuckle.

162-2.7 POSTS, FRAMES, RAILS, AND BRACES. The posts, frames, rails, and braces shall be hot-dip galvanized copper-steel conforming to A. S. T. M. Designation A-7 with a minimum copper content of 0.20 percent.

162-2.8 GALVANIZING. All ferrous metal, for use above or below ground, shall be galvanized with a coating sufficiently heavy to withstand twelve (12) one-minute dips by the standard Preece Test.

162-2.9 WELDING. Structural members of gates which are in contact shall be fully welded by a method that will procure a continuous weld on all sides and faces of joints at exposed edges. Surplus welding material shall be removed.

162-2.10 CONCRETE. Concrete shall be 1:2½:5 mix of approved materials, placed in accordance with Item P-610.

CONSTRUCTION METHODS

162-3.1 GENERAL. The fence shall be constructed in accordance with the details on the plans and as specified herein, with new materials, and all work shall be performed in a workmanlike manner satisfactory to the engineer. Prior to the beginning of the work, or upon the request of the contractor, the engineer shall locate the position of the work by establishing and marking the property line or fence line. At locations of small natural or drainage ditches where it is not practical to conform the fences to the general contour of the ground surface, the contractor, when directed, shall span the opening below the fence with barbed wire fastened to stakes of such length as required. The new fence shall be permanently tied to the terminals of existing fences whenever required by the engineer. The finished fence shall be plumb, taut, true to line and ground contour, and complete in every detail. When directed, the contractor will be required to stake down the chain-link fence at several points between posts.

When directed, in order to keep stock on adjoining property inclosed at all times, the contractor shall arrange the work so that construction of the new fence will immediately follow the removal of existing fences. The length of unfenced section at any time shall not exceed three hundred (300) feet, or such length that the stock can be kept in the proper field. The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the unremoved existing fence. Openings in the fence shall not be left unguarded when stock is using the adjoining property.

162-3.2 CLEARING FENCE LINE. The site of the fence shall be sufficiently cleared of obstructions and surface irregularities shall be graded so that the fence will conform to the general contour of the ground. The fence line shall be cleared to a minimum width of two (2) feet on each side of the center line of the fence. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. Stumps within the cleared area of the fence line shall be grubbed or excavated. The bottom of the fence shall be placed a uniform distance above the ground, as specified on the plans. When shown on the plans, or as directed by the engineer, the existing fences which coincide with or are in a position to interfere with the new fence location, shall be removed by the contractor as a part of the construction work, unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other material acceptable to the engineer, and shall be compacted properly with tampers.

The work shall include the handling and disposal of all material cleared, excavated, or removed, regardless of the type, character, composition, or condition of such material encountered.

162-3.3 INSTALLING POSTS. All posts shall be spaced not more than ten (10) feet apart as shown on the plans. Terminal (end,

corner, pull, and brace) and gate posts shall be set thirty-six (36) inches in concrete bases as shown on the plans. All line posts shall be set thirty (30) inches in concrete bases as shown on the plans. The top of the concrete bases shall be slightly above the ground, trowel finished, and sloped to drain away from the posts. Holes of full depth and size for the concrete bases for posts shall be dug to the size and depth as shown on the plans. Blasting of rock or other obstructions shall be done if necessary. All post settings shall be done carefully so that all posts shall be vertical and in true alignment and rigidly secured in position.

On terminal (end, corner, pull, and brace) and gate posts, the post tops and brace rail clamps around the posts shall be placed before setting the posts in the concrete bases. In setting the gate posts, great care must be taken to make sure that gate posts are set the exact distance apart as shown on the plans. For example, posts for a six (6) foot gate must be set so as to leave an opening exactly six (6) feet wide. A line drawn across from the top of one gate post to the other must be level, regardless of the grade at the ground line. If the ground is not level, the upgrade gate post shall be set first to get the proper height for the downgrade gate post. The concrete bases for end, corner, pull, brace, and gate posts shall be placed first and allowed to cure for fourteen (14) days. The concrete bases for line posts shall be allowed to cure for seven (7) days. Stretcher bar bands and truss bands as called for on the plans shall be spread and slipped on end, corner, pull, brace, and gate posts as the next operation. Post tops are then inserted on all other posts. No extra compensation will be made for rock excavation. Rock excavation shall not be grounds for extension of time.

162-3.4 INSTALLING TOP RAILS. To start the installation, a length of top rail shall be run through the first couple of post tops; a rail clamp shall be assembled on the end, corner, or gate post, as the case may be. The end of the rail already placed shall be butted into the clamp and fastened. The top rail shall be installed along the run of the fence and the various sections joined with sleeve couplings. At not more than every one hundred (100) feet an expansion coupling shall be placed to take care of expansion and contraction of the rail. The rail shall be clamped in the end, corner, or gate post at the end of the run of the installation of top rail.

162-3.5 INSTALLING BRACES. All horizontal braces shall be attached together with truss rods at all terminal (end, corner, and pull) and gate posts to the brace posts as shown on the plans.

162-3.6 INSTALLING FABRIC. The fabric shall be unrolled on the outside of the fence line with the bottom edge of the fabric against posts. The various rolls shall be spliced by bringing the ends close together and weaving in a picket in such a way that it will engage both of the roll ends and catch with each twist each separate mesh of the end pickets of both rolls of fabric. The fabric shall be raised and tied loosely to the top rail with a temporary tie wire at intervals of about twenty (20) feet. The fabric shall be installed by a method ap-

proved by the engineer. One method used is given below. At end, corner or gate posts, the stretcher bar shall be slipped through the end picket of the fabric and the stretcher bar bands at the same time. Then the bolts in the stretcher bar bands shall be tightened. Additional rolls of fabric shall be spliced and placed as the erection progresses along the fence. In long sections, the fence shall be stretched at intervals of about one hundred (100) feet. After the stretching is complete the fabric shall be tied to the top rails with No. 6 gauge galvanized wire clips securely clinched at the back of the rail. The fastenings shall be spaced not more than twenty-four (24) inches on centers for the top rail. The fabric shall be attached to the line posts with No. 6 gauge galvanized wire clips securely clinched to the back of the line posts. The fastenings shall be spaced not more than fourteen (14) inches on centers for line posts. The topmost clip shall be placed on the line post as near the top of the fabric as possible and the lowest clip as near the bottom of the fabric as possible. At terminal (end, corner, and pull) and gate posts the fabric shall be fastened with stretcher bars and bands. The fastenings shall be spaced not more than fourteen (14) inches on centers for terminal (end, corner, and pull) and gate posts. The topmost band shall be placed on these posts as near the top of the fabric as possible and the lowest band as near the bottom of the fabric as possible.

Standard chain-link fence stretching equipment shall be provided for stretching the fabric before tying it to the rails and posts. The stretching and tying operations shall be repeated about every one hundred (100) feet until the run of fence is completed. Equipment of one type for performing the stretching operation may be composed of four pieces of lumber (2 x 4's or larger) cut to a slightly shorter length than the width of the fabric. The pieces shall be bored for six bolts of about $\frac{1}{2}$ -inch or $\frac{5}{8}$ -inch diameter and shall be assembled as shown on the plans. One pair shall be used for stretching the fabric and both pairs shall be used for making a closure of a run of the fence.

Before making a closure the other end of the run shall be fastened to the end, corner, or gate post as described previously. The operation of making a closure of a run shall be as follows. The stretching equipment as described above shall be clamped on the ends of the fabric parallel to each other and about five (5) feet apart when the tension is first applied. The stretching shall continue until the slack has been removed from both sections of the fabric. If the ends overlap, the fabric shall be cut to match. The ends shall be joined by the insertion of a picket similar to the method of connecting two rolls of fabric.

162-3.7 INSTALLING GATES. The gates shall be hung on gate fittings as shown on the plans. The lower hinge (ball and socket type) shall be placed on top of the concrete footing in which the gate post is set; the concrete in the footing shall extend up to the bottom of the lower hinge. The sockets for the cane or foot bolts shall be set in concrete so that the plunger pin will fit perfectly in the socket when the gate is in a closed position. Gates shall be so

erected as to swing in the direction indicated and shall be provided with gate stops as specified or as shown on the plans. Gates shall be erected in suitable places as directed by the engineer or as shown on the plans. All hardware shall be thoroughly secured, properly adjusted, and left in perfect working order. Hinges and diagonal bracing in gates shall be adjusted so that gates will hang level.

162-3.8 EXISTING FENCE CONNECTIONS. Wherever the new fence joins an existing fence, either at a corner or at the intersection of straight fence lines, a corner post with a brace post shall be set at the junction and braced the same as herein described for corner posts or as shown on the plans.

If the connection is made at other than the corner of the new fence the last span of the old fence shall contain a brace span.

162-3.9 CLEANING UP. The contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., belonging to him or used under his direction during construction.

METHOD OF MEASUREMENT

162-4.1 Fences, Class "E," shall be measured in place from outside to outside of end posts or corner posts and shall be the length of fence actually constructed, except the space occupied by the gates.

Driveway gates and walkway gates shall be measured in units for each gate installed and accepted.

BASIS OF PAYMENT

162-5.1 Fences, Class "E," shall be paid for at the contract unit price per linear foot complete in place, which price and payment shall constitute full compensation for clearing the fence line; for furnishing handling, erecting, and placing all materials; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Gates shall be paid for at the contract unit price each per driveway gate and per walkway gate complete in place, which price and payment shall constitute full compensation for furnishing, handling, erecting all materials complete with fittings; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item P-162-5.1 Fence, Class "E"—per linear foot.

Item P-162-5.1 Driveway Gates—per each.

Item P-162-5.1 Walkway Gates—per each.

ITEM P-163 WOOD PICKET FENCES (Class "F")

DESCRIPTION

163-1.1 This item covers the requirements for furnishing materials and constructing new wood picket fences and gates in accordance with the details included herein and as shown on the plans.

MATERIALS

163-2.1 POSTS. (a) *Species.* All posts shall be one of the following species of wood unless otherwise noted in the proposal:

Group I

Cedar
Chestnut
Cypress, Southern
Locust, Black
Osage-orange
Redwood
Yew, Pacific
Honey Locust
Oak, White
Mulberry
Live Oak

Group II

Douglas Fir
Gum, Red
Larch, Western
Pine, Southern Yellow
Pine, Lodgepole
Tamarack
Ash
Maple, Sugar
Oak, Red
Spruce

Posts of Group I may be used untreated provided at least seventy-five (75) percent of the wood is heartwood; posts of less than seventy-five (75) percent heartwood of Group I shall be given a preservative treatment for the part of the post that will have contact with the ground and for a distance of at least six (6) inches above the ground line in accordance with the method specified under subparagraph (d)-1, below. Posts of Group II shall be given a preservative treatment in accordance with the method specified under subparagraph (d)-2, below.

(b) *Quality.* Posts shall be sound, straight-grained, free from decay, cracks, and splits; shakes shall not be in excess of one-fourth ($\frac{1}{4}$) inch wide and three (3) feet long. Checks (lengthwise separations of the wood in a generally radial direction) are permitted, provided they are not injurious.

(c) *Dimensions.* All posts shall be the length and size shown on the plans.

(d) *Treatment*—1. **BUTT TREATMENT.** All timber shall be thoroughly seasoned and dry (twenty-two (22) percent maximum mois-

ture content) before applying preservative treatment. The treatment shall be by a process at least equal to a hot and cold bath process. The hot bath temperature shall be from 200° F. to 230° F. for a duration of forty-five (45) minutes, and the cold bath temperature not over 120° F. for a duration of forty-five (45) minutes. The preservative shall be either coal-gas tar or coke-oven tar creosote conforming to American Wood Preservers Association Specification No. 4 for Grade 1 creosote; or a five (5) percent minimum, by weight, pentachlorophenol petroleum solution made by either mixing a liquid concentrate of pentachlorophenol in fuel oil or kerosene, or by dissolving pentachlorophenol crystals of technical purity in suitable fuel oil solvents.

2. **FULL LENGTH TREATMENT.** Posts shall be conditioned by air seasoning, by steaming, or by heating in oil in such a manner as will not cause injurious checking, splitting, or warping before treating. The treatment shall be by an empty-cell process with final retention of six (6) pounds preservative per cubic foot of wood in charge in accordance with the applicable A. W. P. A. Specification. The preservative shall be either coal-gas tar or coke-oven tar creosote conforming to A. W. P. A. Specification No. 4 for Grade 1 creosote; or a five (5) percent minimum, by weight, pentachlorophenol petroleum solution. The pentachlorophenol solution shall be made by mixing a liquid concentrate of pentachlorophenol in fuel oil or kerosene, or by dissolving pentachlorophenol crystals of technical purity in suitable fuel oil solvents.

Corner, anchor, and gate posts shall have all required gains and notches for braces painted with creosote after cutting.

163-2.2 RAILS, BRACES, ETC. Rails, braces, cleats, blocks, fillers, and gate stops shall be of the size shown on the plans. They shall be of the same species and quality specified for the posts, or approved by the engineer, and shall be free from knots larger than one-third ($\frac{1}{3}$) the width of the piece. All cleats, gate stops, and any braces in contact with the ground and for a distance of at least six (6) inches above the ground shall be treated by the hot and cold bath process specified herein for posts.

163-2.3 PICKETS. (a) *Species.* All pickets shall be one of the following species of wood unless otherwise noted in the proposal:

Cypress, Southern
Redwood

Douglas Fir
Red Cedar, Western

(b) *Quality.* The pickets shall be No. 1 grade meeting the current standard specifications of the respective lumber associations.

(c) *Dimensions.* All pickets shall be of the length and size shown on the plans.

163-2.4 HARDWARE. Each gate section shall be provided with a high-grade, heavily galvanized hardware, as shown on the plans.

163-2.5 PAINT. White or tinted ready-mixed paint (lead-zinc base) shall meet American Association of State Highway Officials Specification M-70.

CONSTRUCTION METHODS

163-3.1 GENERAL. The fence shall be constructed in accordance with details on the plans and as specified herein, with new materials, and all work shall be performed in a workmanlike manner satisfactory to the engineer. Prior to the beginning of the work, or upon the request of the contractor, the engineer will locate the position of the work by establishing and marking the property line or fence line. The new fence shall be permanently tied to the terminals of existing fences whenever required by the engineer.

163-3.2 CLEARING FENCE LINE. The site of the fence shall be sufficiently cleared of obstructions and surface irregularities shall be graded so that the fence will conform to the general contour of the ground. The fence line shall be cleared to a minimum width of two (2) feet on each side of the center line of the fence. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. Stumps within the cleared area of the fence line shall be grubbed or excavated.

The bottom of the fence shall be placed a uniform distance above ground, as specified on the plans.

When shown on the plans, or as directed by the engineer, the existing fences which coincide with, or are in a position to interfere with the new fence location, shall be removed by the contractor as part of the construction work, unless such removal is listed as a separate item in the schedule.

All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other material acceptable to the engineer, and shall be properly compacted by the use of tampers.

The work shall include the handling and disposal of all material cleared, of excess excavation and the removal of spoil material, regardless of the type, character, composition, or condition of such material encountered.

163-3.3 SETTING POSTS. Posts shall be set full depth as shown on the plans, and shall not be cut off or altered to eliminate rock or other excavation. The diameter of the holes shall be at least six (6) inches larger than the posts. When cleats are used on posts, the holes shall be dug large enough to accommodate them. Where rock is encountered, it shall be removed by blasting if necessary to provide full depth and size holes. After the post is placed and lined the hole shall be backfilled with suitable material which shall be properly compacted by the use of tampers.

163-3.4 ANCHORING. Corner and end posts shall be anchored by gaining and spiking cleats to the side of the posts, as indicated on the plans.

163-3.5 INSTALLING GATES. The gates shall be hung on gate fittings as shown on the plans. Fittings on the gate posts shall be screwed or bolted to prevent slipping. Single leaf gates shall be

erected so as to swing in the direction indicated. Double leaf gates shall be erected so as to swing in the direction indicated, and shall be provided with gate stops, as specified, or as shown on the plans. Gates shall be erected at suitable places as directed by the engineer or as shown on the plans.

163-3.6 EXISTING FENCE CONNECTIONS. Whenever the new fence joins an existing fence, either at a corner or the intersection of straight fence lines, a corner or end post shall be set at the junction and anchored the same as herein described for corner posts, and as shown on the plans.

163-3.7 PAINTING. After erection, the entire fence and gates shall have all knots sealed with a thin coat of shellac, varnish, or a heavy coat of white lead paint, then primed with one coat of white lead paint. A finish coat shall be applied of white or tinted ready-mixed paint (lead-zinc base) meeting A. A. S. H. O. Specification M-70.

The surface of the rail to which the pickets are nailed shall be given a prime coat before the pickets are nailed in place. The surfaces of the posts that have been treated with creosote shall not be painted.

163-3.8 CLEANING UP. The contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., belonging to him, or used under his direction during construction.

METHOD OF MEASUREMENT

163-4.1 Wood picket fences shall be measured in place from outside to outside of end posts or corner posts and shall be the length of fence actually constructed, except the space occupied by the gates.

Driveway gates and walkway gates shall be measured in units of each gate installed and accepted.

BASIS OF PAYMENT

163-5.1 Wood picket fences shall be paid for at the contract unit price per linear foot, complete in place, which price and payment shall constitute full compensation for clearing the fence line; for furnishing, handling, building, and placing of all materials; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Gates shall be paid for at the contract unit price per driveway gate and per walkway gate complete in place, which price and payment shall constitute full compensation for furnishing, handling, building, erecting all materials complete with fittings; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- Item P-163-5.1 Wood Picket Fence—per linear foot.
- Item P-163-5.1 Driveway Gates—per each.
- Item P-163-5.1 Walkway Gates—per each.

FLEXIBLE BASE COURSES

ITEM P-201 BITUMINOUS BASE COURSE (Central Plant Hot Mix)

DESCRIPTION

201-1.1 This item shall consist of a base course composed of mineral aggregate and bituminous material, mixed in a central mixing plant and placed on a prepared course, in accordance with these specifications and in conformity with the dimensions and typical cross sections shown on the plans and with lines and grades established by the engineer.

When called for or shown on the plans, the base shall be constructed in two or more courses: a leveling course, a binder or base course. Each shall be constructed to the depth, typical section, or elevation required by the plans. The leveling, binder or base course shall be rolled, finished, and approved before the placement of an additional layer or the surface course, in the manner specified.

201-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight, to be added to the aggregate shall be fixed by the engineer on the basis of preliminary laboratory tests and field sieve analysis on the aggregate furnished, and shall be within the range as shown in the table.

201-1.3 JOB MIX FORMULA. No work shall be started on the project nor any mixture accepted therefor until the contractor has submitted samples of the materials intended for use and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate and for bituminous cement; also the intended temperature of completed mixture at the time it is discharged from the mixer. The material furnished shall conform to the approved job mix formula within the tolerances specified herein:

JOB MIX TOLERANCES

	Plus or minus
Aggregate passing sieves No. 4 and larger.....	5 percent
Aggregate passing Nos. 10, 40, and 80 sieves.....	4 percent
Aggregate passing No. 200 sieve.....	2 percent
Asphaltic cement.....	0.4 percent
Tar	0.4 percent
Temperature of mixing and placing.....	25° F.

MATERIALS

201-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, crushed slag, screenings, gravel, sand-gravel, sand, or other natural, granular, and approved material having essentially the same qualities and meeting all the requirements when combined within the limits for gradation.

The aggregate shall be tough, durable, and sound. The aggregate shall consist of angular fragments reasonably uniform in density and quality and shall not contain more than eight (8) percent of either thin, elongated and soft pieces, or dirt, or other objectionable matter. The coarse aggregate, when tested in accordance with the Los Angeles Rattler Test, after five hundred revolutions shall have a percent of wear of not more than forty-five (45) according to the A. A. S. H. O. Method T-96. The coarse aggregate shall not show evidence of disintegration, nor show a total loss greater than 12 percent when subjected to five cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

Slag shall be air cooled, blast furnace slag, and shall have a compact weight of not less than seventy (70) pounds per cubic foot.

The portion of the material retained on a No. 4 mesh sieve shall be known as coarse aggregate; that portion passing a No. 4 mesh sieve shall be known as fine aggregate, and the material passing the No. 200 mesh sieve shall be known as filler. The composite material shall meet the requirements for one of the gradations given in Tables 1 or 2 using A. A. S. H. O. Methods T-11 and T-27.

That portion of the fine aggregate, including any blended filler, passing a No. 40 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91, and liquid limit of not more than 25 as determined by A. A. S. H. O. Method T-89.

The composite aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The bituminized aggregate shall have a swell of not more than one and one-half (1½) percent as determined by A. A. S. H. O. Method T-101.

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample of the paving mixture in conformity with the specifications contained herewith. After the mixture has been made it shall be spread out in a loose thin layer and allowed to air season for twenty-four (24) hours before testing. A suitable size sample (approximately one-half contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap. The sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable

material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing off of the bituminous coating occurs, it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state or the aggregate shall be rejected.

201-2.2 FILLER. If filler in addition to that naturally present in the aggregate is necessary, it shall consist of stone dust, loess, Portland cement or other approved mineral matter. Stone dust shall be specified and used with sand-asphalt base courses. The filler material shall meet the requirements of A. A. S. H. O. Specification M-17.

201-2.3 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregates at the central plant shall conform to the grade, requirements, and specifications as follows: Asphalt cement or tar may be used in the base, binder or leveling course, unless otherwise specified in the proposal.

The asphalt cement for hot central plant mix shall meet the requirements of A. A. S. H. O. Specification M-20 or M-22. The penetration of the petroleum asphalt cement shall be between 100 and 150. The penetration of native asphalt cement shall be between 85 and 150. A limited range or grade shall be selected for each project such as 85-100, 100-120, or 120-150. The penetration grade shall be indicated in the proposal, shown on the plans or as directed by the engineer. The petroleum asphalt cement shall not be cracked.

NOTE: When native asphalt cement contains mineral filler, the penetration grade selected will depend upon the amount of inorganic filler present.

The tar shall meet the requirements of A. A. S. H. O. Specification M-52. The grade shall be RT-10, RT-11, or RT-12. The grade shall be indicated in the proposal, shown on the plans, or as directed by the engineer.

201-2.4 HYDRATED LIME. The hydrated lime shall meet the requirements of the A. S. T. M. Designation C-6.

COMPOSITION

201-3.1 COMPOSITION OF MIXTURE. The mineral aggregate for the base course shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to one of the following gradations. The percent by weight for the bituminous material shall be within the limits given.

TABLE 1.—*Aggregate-Bituminous Base Course*

Sieve size	Percentage passing sieves (square openings)			
	A 1¼" maxi- mum	B 1" maxi- mum	C ¾" maxi- mum	D ½" maxi- mum
1¼ inch.....	100			
1 inch.....	86-100	100		
¾ inch.....	68- 92	82-100	100	
½ inch.....	55- 84	70- 90	82-100	100
⅜ inch.....	46- 76	60- 82	68- 90	82-100
No. 4.....	32- 64	42- 70	50- 79	56- 88
No. 10.....	20- 50	30- 60	36- 67	40- 75
No. 40.....	8- 30	15- 40	17- 44	19- 48
No. 80.....	4- 19	8- 26	9- 29	10- 32
No. 200.....	3- 8	3- 8	3- 8	4- 9
Bituminous material, percent:				
Asphalt cement:				
Stone, or gravel.....	4.0-6.0	4.5-6.5	5.0- 7.5	5.5- 8.0
Slag.....	5.0-7.5	6.0-8.5	6.5-10.0	7.0-10.5
Tar:				
Stone, or gravel.....	3.5-5.0	4.0-5.5	4.5- 6.5	5.0- 7.0
Slag.....	4.5-6.5	5.0-7.0	6.0- 8.5	6.5- 9.0

TABLE 2.—*Sand-Bituminous Base Course*

[This table will not be considered unless its use is permitted in the proposal.]

Sieve size	Percentage passing sieves (square openings)
	E ¾" maximum
½-inch.....	100
⅜-inch.....	91-100
No. 4.....	75-100
No. 10.....	56- 85
No. 40.....	24- 56
No. 80.....	12- 37
No. 200.....	4- 10
Bituminous Material, Percent:	
Asphalt Cement.....	5.5-7.5
Tar.....	5.0-6.5

In the table the percentages of asphalt cement and tar are given for stone, gravel, and slag aggregates. If the total aggregate is composed of slag, the percentages of bituminous material shown shall be used. Where only a part of the aggregates is slag, the increase in bituminous material shall be made in a corresponding proportion.

The gradations in these tables represent the limits which shall determine suitability of aggregate for use from the sources of supply.

The final gradations decided on within the limits designated in the tables shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The selection of any of the gradations shown in the tables shall be such that the maximum size aggregate used shall not be more than two-thirds ($\frac{2}{3}$) of the thickness of the layer of the base course being constructed.

A sample of the coarse and fine aggregates shall be washed to determine the percentage of the total material passing the No. 200 mesh sieve. Of the amount of the material passing the No. 200 mesh sieve, at least one-half ($\frac{1}{2}$) shall pass the No. 200 mesh sieve by dry sieving.

The composition limits tabulated shall govern but a closer control appropriate to the job materials will be required for the specific project in accordance with a job mix formula.

The weights for the measurement of the bituminous mixtures should be based on the bulk specific gravity of aggregates of 2.65. Proportionate corrections shall be made when the aggregates furnished on the job (job aggregate) have bulk specific gravities above 2.75 or below 2.55.

CONSTRUCTION METHODS

201-4.1 WEATHER AND SEASONAL LIMITATIONS.

The base course shall be constructed only when the surface upon which it is to be placed is dry, when the atmospheric temperature is above 40° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

201-4.2 EQUIPMENT. (a) *General.* All methods employed in performing the work and all equipment, tools, and other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The paving plant used by the contractor in the preparation of the bituminous concrete shall comply with the following requirements:

The drier shall be suitably designed to heat and dry the aggregate to specification requirements and to continuously agitate the aggregate during heating. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant to meet the specification requirement. A dial thermometer or other approved thermometric instrument shall be so placed at the discharge chute of the drier as to automatically register or indicate the temperature of the heated aggregate.

All plant screens shall be designed, constructed, and operated so as to screen all aggregates to appropriate fractions as established by the engineer and as necessary to meet the job mix tolerances.

The plant shall have storage bins, protected from the weather, of sufficient capacity to furnish the necessary amounts of all aggregates when operating at the maximum rated capacity of the plant. The bins shall provide three or more compartments for hot aggregates of three-quarter ($\frac{3}{4}$) inch maximum size or larger gradations and two or more compartments for one-half ($\frac{1}{2}$) inch maximum size aggregate or smaller, so proportioned as to insure adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe or other device which meets the approval of the engineer, of such size and at such locations as to prevent backing up of material into other compartments. When required by the engineer, a dial thermometer or other approved thermometric instrument shall be so placed in the bin over the mixer as to automatically register or indicate the temperature of the heated aggregate immediately before it enters the mixer. The dial or other indicator shall be plainly visible from the mixing platform.

Adequate and dry storage for mineral filler shall be separately provided. Provisions shall be made for the weighing of filler by separate approved scales or by a separate beam on the weigh box scales.

The plant shall have a batch weighing device for the dried mineral aggregates. This equipment shall be constructed for easy adjustment of any working part so that it will function properly and accurately. The weigh box or hopper shall be supported on fulcrums and knife edges so made that they will not be easily thrown out of alignment or adjustment. The hopper must be free from contact on all edges, ends, or sides with any supporting rods or columns or other equipment that will in any way affect its proper functioning. In addition there must be sufficient clearance between the hopper and supporting devices so that foreign materials will not accumulate. The discharge gate of the hopper shall be so hung that the aggregates will not be segregated when dumped in the mixer. If necessary to correct any such tendency, baffles shall be inserted or other means provided to discharge the materials in a blended condition. The plant shall have a capacity of at least forty (40) tons per hour.

Scales for the weigh box may be either of the beam or springless dial type and shall be a standard make and design, sensitive to one-half ($\frac{1}{2}$) of one percent of the maximum load that may be required. When of the beam type, there shall be a separate beam for each size of aggregate and there shall be a "telltale" dial scale attached. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. Beam scales shall be balanced on knife edges and fulcrums and be so constructed that they cannot be easily thrown out of alignment and adjustment. Dial scales shall be of a standard make and of sufficient size that the numerals on the dial can be read at a distance of not less than twenty-five (25) feet. All dial scales shall be so located that they will be in plain view of the operator at all times.

Scales for the weighing of asphalt cement shall conform to the specifications for the aggregate scales except that beam scales shall be

equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not be greater than two (2) pounds. Dial scales for weighing the asphalt cement shall have a capacity of more than twice the weight of the material to be weighed and shall read to the nearest pound.

The contractor shall provide and have at hand the necessary number of standard test weights for frequent testing of all scales.

The asphalt weigh bucket shall be steam jacketed or be insulated with other temperature controls. It shall be supported on fulcrums and knife edges in the same manner as the weigh box and have a capacity equal to twelve (12) percent by weight of the maximum capacity of the mixer.

The mixer shall be a standard twin pug mill type of sufficient size to maintain thorough uniform mixing at the rated plant capacity. The mixer shall be equipped with a sufficient number of paddles or blades set in the proper order and position to produce a satisfactory mixture of any material required under these specifications. When the clearance is equal to or exceeds two (2) inches, either the shortened blades or the worn liners (or both) shall be replaced to reduce the clearance to two (2) inches or less. If sufficient mixing and coating is not secured at the minimum mixing time specified the right is reserved to increase the required mixing time as may be judged necessary by the engineer. The mixer shall be steam-jacketed or properly insulated with other temperature controls. The capacity of the mixer shall be at least 1,200 pounds.

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

Equipment for heating bituminous material shall consist of kettles or tanks with steam coils or other suitable heating devices. Under no circumstances shall a direct flame come in contact with the heating kettles; steam coils shall be so designed that steam will not be introduced into the material. A recording thermometer shall be provided, which will record the temperature of the bituminous material at the draw-off valve.

Asphalt storage and supply lines shall be insulated or steam jacketed in such a manner that there will be no appreciable drop in temperature of the asphalt between the heating unit and the mixing unit.

A volumetric proportioning, continuous mixing type of plant may be substituted for the above weigh batch type when approved by the engineer and provided the equipment has demonstrated that it is suitable in producing the required gradation control of aggregates and uniformity of mixture. The number of bin compartments provided shall be the same as stipulated above for batch-type plant. The plant shall include a feeder mounted under the bin compartments and a means of accurately proportioning each bin size of aggregate by accurately controlled individual gate to form an orifice for measuring

the material. The orifice shall be rectangular, of dimensions about eight (8) inches by nine (9) inches with one dimension adjustable by positive mechanical means and provided with a lock. Indicators shall be provided on each gate to show the gate opening in inches. There shall be included a means for calibrating the gate openings by means of weight test samples. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be adjustable and, after being set, shall be capable of remaining fixed. The paddles of the continuous mixer shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and also giving the rate of feed of aggregate per minute at plant operating speed.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading, shaping, or finishing will be required to provide a surface which will comply with the requirements for thickness and smoothness contained herein.

(d) *Rolling Equipment.* Rollers shall be suitably designed for the construction of bituminous pavements. The rolling shall be done with self-propelled tandem and three-wheel type rollers weighing not less than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking.

201-4.3 PREPARATION OF MINERAL AGGREGATE.

The aggregate for the mixture shall be dried and heated at the paving plant before entering the mixer. When introduced into the mixer the combined aggregate shall not contain more than one (1) percent moisture if asphalt is used or more than three (3) percent for tar mixtures. Water in the aggregate shall be removed by heating to the extent that no subsequent foaming shall occur in the mixture prior to the placing of the material. The aggregate shall be heated to the temperature as designated by the job formula within the job tolerances specified. The maximum temperature and the rate of heating shall be such that no permanent damage occurs to the aggregates. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by heating. The aggregates shall be screened to specified sizes and conveyed into separate bins ready for mixing with bituminous material.

Additional filler, if necessary to meet the gradation requirements, shall be proportioned and added to the mineral aggregate. Filler may be added to the aggregate at the mixing plant by premixing it thoroughly with the other aggregates. Spreading filler over the tops

of the aggregate pits or dumping it into the hoppers at crushing plants will not be permitted.

201-4.4 PREPARATION OF BITUMINOUS MIXTURE.

Before being delivered to the runway, the aggregate shall be mixed with the bituminous material at a central mixing plant. The mixture shall be prepared at a temperature as directed by the engineer between 175° to 250° F. for tar mixtures and 225° to 300° F. for asphalt mixtures.

The dry aggregates, prepared as described above, shall be combined in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured and conveyed into the mixer. In case of volumetric proportioning, the size of the gate openings shall be determined and the gates locked in position.

The bituminous material shall be melted in kettles or tanks designed to secure uniform heating of the entire contents. Tar shall not be heated over 250° F. and asphalt shall not be heated over 325° F.

Kettles for storage of bituminous cement shall have a total capacity sufficient for one day's run and shall be capable of heating the bituminous cement with an effective and positive control of the heat at all times to a temperature between 175° F. and 350° F. Heating of the cement by steam coils is preferred. The circulating system shall be constructed of adequate size to give the proper and continuous circulation of cement throughout the operating periods. All lines and fittings shall be insulated or steam-jacketed.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the engineer, and shall be measured by weight and introduced into the mixer at the specified temperature, holding to the lowest range possible for adequate mixing and spreading. For batch mixers all mineral aggregate shall be in the mixer before the bituminous material is added. The exact temperature to be used on the work within the specified range shall be fixed by the engineer. In no case shall aggregate be introduced into the mixture at a temperature more than 25° F. above the temperature of the bituminous material. The mixing shall continue for at least thirty (30) seconds and for such longer period as may be necessary to coat all of the particles.

From zero (0) to one (1) percent of Portland cement or hydrated lime shall be added to the composition of the asphalt mixture when provided for in the proposal.

201-4.5 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be transported from the mixing plant to the point of use in pneumatic-tired vehicles having tight bodies previously cleaned of all foreign materials. When directed by the engineer, each load shall be covered with canvas or other suitable material of sufficient size and thickness to protect it from the weather or dust conditions.

The mixture shall be placed at a temperature between 150° and 225° F. when tar is used, and between 200° and 300° F. when asphalt cement

is used. When the mixture is being placed during warm weather and the engineer has determined that satisfactory results can be obtained at lower temperatures, he may direct that the mixture be mixed and delivered at the lower temperatures.

No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during daylight, unless artificial light satisfactory to the engineer is provided. The mixture shall be delivered at a temperature within the tolerance allowed in the approved job formula.

201-4.6 SPREADING AND LAYING. (a) *Preparation for placing.* Immediately before placing the bituminous mixture, the existing underlying course shall be cleaned of loose or deleterious material by sweeping with a power sweeper equipped with blower, supplemented by hand brooms if necessary, or as directed by the engineer.

The mixture shall be laid only upon an approved underlying course which is dry, which is in a suitable condition, and only when weather conditions are suitable. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 40° F. or under, unless so directed by the engineer. The engineer may, however, permit work of this character to continue when overtaken by sudden rains, up to the amount which may be in transit from the plant at the time, provided the mixture is within the temperature limits specified.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the center line of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall commence at the point or points furthest from the mixing plant, and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed shall not be permitted until the material has been compacted thoroughly in the manner specified, and allowed to cool to atmospheric temperature.

Normally the base course will be laid in a compacted layer up to three (3) inches in depth. When the base course is to be constructed in thickness greater than three (3) inches the course shall be placed in two or more layers.

(b) *Machine Spreading.* Upon arrival the mixture shall be dumped into an approved mechanical spreader and immediately spread thereby to the full width required. It shall be struck off in a uniform layer of such depth that when the work is completed it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate the pulling and tearing of the bituminous material.

Placing and compaction of the bituminous mixture shall progress in sections. The bituminous mixture shall be spread, shaped, and finished with the power-machine specified. The mixture shall be placed in strips of a minimum width of ten (10) feet. To insure proper drainage, the spreading shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope. The six (6) inch strip adjacent to

the area on which future material is to be laid shall not be rolled until such material has been placed, but shall not be left unrolled more than two (2) hours after being placed. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted as provided for the first width, except that rolling shall be extended to include the six (6) inches of the first width not previously compacted. Whenever the adjacent or second width cannot be placed within two (2) hours, the six (6) inch strip shall not be left unrolled. After the second strip has been placed and rolled, a straightedge (minimum length of ten (10) feet) shall be used across the longitudinal joint to determine if the course is to grade and contour.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If for any reason the spreading machine should drift away from an adjacent lane during construction, the unfilled space so made shall be carefully filled with fresh hot mixture obtained from the hopper of the spreading machine or from the truck. Stealing mixture from that already spread to fill up these areas shall not be permitted.

In limited areas where, on account of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impractical, the mixture may be spread by hand.

When hand spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread and be distributed into place immediately by means of hot shovels. It shall be spread with hot rakes in a uniformly loose layer to the full width required and of such depth that where the work is completed, it will have the required thickness and will conform to the grade and contour shown on the plans.

Contact surfaces shall be painted with a thin uniform coat of hot asphalt cement, cut-back asphalt, or emulsion just before the mixture is placed. Tar shall be used when tar is contained in base or binder course.

201-4.7 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, the mixture shall be thoroughly and uniformly compacted by a power driven, three-wheel roller and tandem roller or rollers, weighing eight (8) tons or more. Rolling of the mixture shall begin as soon after spreading as it will bear the roller without undue displacement or hair checking. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the other edge.

Initial rolling shall be done longitudinally with tandem rollers and/or three-wheel rollers. The rollers shall overlap on successive trips. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling crossing the lines of the first after three or more lanes are constructed but cross rolling shall not exceed more than one-half ($\frac{1}{2}$) width of the runway.

The speed of the roller shall at all times be slow enough to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes, and of fresh mixture where required.

Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant. Rolling shall proceed at an average rate not to exceed 350 square yards per hour per roller. Rolling shall continue until the course is of uniform texture and true to grade, to cross section, and the density of at least ninety-two (92) percent of the theoretical density is obtained. Field density tests shall be made at least twice daily. Final rolling shall be done with tandem rollers.

The theoretical density shall be computed as follows:

$$\text{Density} = \frac{100}{\frac{\% \text{ mineral aggregate by weight}}{\text{Sp. gr. mineral aggregate}} + \frac{\% \text{ bitumen by weight}}{\text{Sp. gr. of bitumen}}}$$

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated by competent and experienced rollermen. The rollers shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression, and be free from objectionable roller marks.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to the application of the finish coat shall be removed and replaced with fresh hot mixture, which shall be immediately compacted to conform with the surrounding area, all to be done at the expense of the contractor. Skin patching on an area that has been rolled shall not be allowed.

201-4.8 JOINTS. (a) *General.* The mixture at the joints shall comply with the contour requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the adjacent course for the full specified depth. Joints shall be formed by cutting back on the previous day's run so as to expose the full depth of the course, and the exposed edge shall be given a light paint coat of asphalt, if necessary. The fresh mixture shall be raked against the joint, thoroughly tamped with tampers, and rolled.

(b) *Transverse.* The placing of the course shall be as nearly continuous as possible. The roller shall pass over the unprotected end of

the freshly laid mixture only when the laying of the course is to be discontinued.

(c) *Longitudinal*. The placing of the course shall be in the manner as specified and so that the joint is exposed for the shortest period possible. The joint shall be placed so that it will not coincide with that in a lower course and will break joints by at least one (1) foot.

201-4.9 SHAPING EDGES. While the course is being compacted and finished the contractor shall carefully trim the outside edges of the pavement to the proper alignment. The edge so formed shall be beveled while still hot with the back of a rake or a smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

201-4.10 SURFACE TESTS. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression and any variation shall be corrected by removing or adding materials and continuing the rolling.

The finished surface of the base shall not vary more than three-eighths ($\frac{3}{8}$) inch when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the centerline.

After the completion of final rolling, the smoothness of the course shall again be tested; the humps or depressions exceeding the specified tolerance or that retain water on the surface shall be immediately corrected by removing the defective work and replacing with new material, as directed by the engineer, and at the expense of the contractor.

201-4.11 SAMPLING PAVEMENT. For the determination of composition, compaction, and density of the pavement the contractor shall remove suitable size samples of the compacted base. Samples for each day or fraction thereof when mixtures are placed shall be taken by the engineer. The contractor shall replace the pavement where samples are removed, and these replacements shall be installed by the contractor free of charge. After the samples have been removed from the completed base they will be tested by the engineer for density and composition. If the deficiency in composition and compaction exceeds the limits of toleration from that specified, satisfactory corrections shall be made.

201-4.12 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

For checking the adequacy of the equipment in use, inspecting the conditions and operation of the plant, for the verification of weights or proportions and character of materials and/or the determination and checking of temperatures being maintained in the preparation

of the mixtures, the engineer or his authorized representative shall have access at any time to all parts of the paving plant.

The contractor shall furnish vendor's certified test report for each carload or equivalent of bitumen shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

201-4.13 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

201-5.1 The tonnage of base course to be paid for shall be the number of tons of bituminous mixture of the gradation called for in the bid schedule and used in the accepted work. The bituminous treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

201-5.2 The quantities as measured in paragraph 5.1, for base mixtures are applicable for aggregates having a bulk specific gravity between 2.55 and 2.75 as determined by A. A. S. H. O. Methods T-84 and T-85. Proportionate corrections shall be made when the aggregate furnish on the job have bulk specific gravities above 2.75 or below 2.55. In the cases where the specific gravity is below 2.55 the correct quantity for payment shall be the product of the number of tons used multiplied by the ratio of 2.55 to the bulk specific gravity of the job aggregate. In the cases where the specific gravity is above 2.75 the correct quantity for payment shall be the product of the number of tons used multiplied by the ratio of 2.75 to the bulk specific gravity of the job aggregate. The intent of the correction is to make the cost of the bituminous pavement approximately the same as when the tonnage is figured at the average specified gravity of 2.65.

201-5.3 The unit of measurement for the bituminous material shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at

other temperatures to gallonage at 60° F. in accordance with A. S. T. M. Designation D-206 for asphalt materials and in accordance with A. S. T. M. Designation D-633 for tar.

BASIS OF PAYMENT

201-6.1 The quantities of base mixture and bituminous material determined as provided in 5.1, 5.2, and 5.3, above, shall be paid for at the respective contract unit prices per ton in the bid schedule for base course and per gallon or per ton for bituminous material, which prices and payment shall constitute full compensation for preparing subbase or underlying course; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas; for reconditioning underlying course and shoulders; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

- Item P-201-6.1 Aggregate—Bituminous Base Course—per ton.
- Item P-201-6.1 Sand—Bituminous Base Course—per ton.
- Item P-201-6.1 Bituminous Material—per gallon or per ton.

ITEM P-204 MIXED IN-PLACE BASE COURSE (Travel-Plant Method)

DESCRIPTION

204-1.1 This item shall consist of a base course composed of mineral aggregate and bituminous material, mixed in a travel plant, constructed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with line and grade established by the engineer.

204-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight, to be added to the aggregate shall be between the limits as set forth in the table. The exact percentage to be used shall be fixed by the engineer on the basis of preliminary tests and field sieve analysis of the aggregate furnished.

204-1.3 JOB MIX FORMULA. No work shall be started on the project nor any mixture accepted until the contractor has submitted samples of the materials intended for use and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate, and for bituminous cement. The material furnished shall conform to the approved job mix formula within the tolerances specified herein:

Job Mix Tolerances

	<i>Plus or minus</i>
Aggregate passing sieves No. 4 and larger-----	6 percent
Aggregate passing Nos. 10, 40, and 80 sieves-----	4 percent
Aggregate passing No. 200 sieve-----	2 percent
Bitumen -----	0.5 percent

MATERIALS

204-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, crushed slag, screenings, gravel, sand-gravel, sand or other natural, granular, approved material having essentially the same qualities and meeting all the requirements when combined within the limits for gradation.

The aggregate shall be tough, durable, and sound. The coarse aggregate when tested in accordance with the Los Angeles Rattler Test,

after five hundred (500) revolutions shall have a percent of wear of not more than fifty (50) according to the A. A. S. H. O. Method T-96.

Slag shall be air cooled, blast furnace, and shall consist of angular fragments reasonably uniform in density and quality and reasonably free from thin, elongated or soft pieces, dirt, or other objectionable matter. The dry slag shall weigh not less than seventy (70) pounds per cubic foot.

The portion of the material retained on a No. 4 mesh sieve shall be known as coarse aggregate; that portion passing a No. 4 mesh sieve shall be known as fine aggregate, and the material passing the No. 200 mesh sieve shall be known as filler. The composite material shall meet the requirements for one of the gradations given in Table 2, using A. A. S. H. O., Methods T-11 and T-27.

No intermediate sizes of aggregate shall be removed for use in the seal coat or for other purposes without the written consent of the engineer.

That portion of the fine aggregate, including any blended filler, passing a No. 40 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91; a liquid limit of not more than 25 as determined by A. A. S. H. O. Method T-89 and a maximum clay content by elutriation of six (6) percent.

The composite aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The bituminized aggregate shall have a swell of not more than one and one-half (1½) percent as determined by A. A. S. H. O. Method T-101.

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample of the paving mixture in conformity with the specifications contained herewith. After the mixture has been made it shall be spread out in a loose thin layer and placed in a constant temperature oven controlled to 140° F. for a period of twenty-four (24) hours before testing. A suitable size sample (approximately one-half (½) contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap; the sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing off of the bituminous coating occurs it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state, or the aggregate shall be rejected.

204-2.2 FILLER. If filler in addition to that naturally present in the aggregate is necessary, it shall consist of stone dust, loess, Portland cement, or other approved mineral matter. The filler ma-

terial shall meet the requirements of A. A. S. H. O. Specification M-17. When called for in the proposal, stone dust shall be used as filler with sand aggregate.

204-2.3 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregate in the travel plant shall conform to the grade, requirements, and specifications as follows:

Rapid curing cut-back asphalt, grade RC-2, RC-3, RC-4—conforming to the requirements of A. A. S. H. O. Specification M-81.

Refined tar, grade RT-5, RT-6, RT-7, RT-8, RT-9—conforming to the requirements of A. A. S. H. O. Specification M-52.

The grade of cut-back asphalt or tar shall be as indicated in the proposal, as shown on the plans, or as directed by the engineer.

The emulsified asphalt shall be homogenous and of such character that it will mix with distilled water in all proportions and shall meet the requirements as contained in Table 1.

TABLE 1.—*Requirements for Emulsified Asphalt*

Test requirements	A. A. S. H. O. test method	Limits
Viscosity, Saybolt Furol, at 77° F., sec.....	T-59	20-120
Residue at 325° F., percent.....	T-59	55-65
Demulsibility: 50 ml. of 0.1 N CaCl ₂ , not more than, percent.....	T-59	30
Sieve Test, not more than, percent.....	T-59	0.05
Settlement 5 days, not more than, percent.....	T-59	5
Stone Coating Test.....	T-59	Shall pass
Sampling Material.....	T-40	-----

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F./77° F., not less than.....	T-43	0.96
Penetration at 77° F., 100 g., 5 sec.....	T-49	150-225
Soluble in Carbon Tetrachloride, not less than, percent.....	T-45	97
Ductility at 77° F., not less than, cm.....	T-51	60

The material shall not be cracked.

The base asphalt for the emulsified asphalt shall have a range of penetration at 77° F., 100 g., 5 sec., of 150-225. The mixture of emulsified asphalt and aggregate after curing shall develop no indication of re-emulsifying due to its coming in contact with moisture or water. The emulsified asphalt shall be of such stability that it will remain constant and uniform while being combined and mixed with the aggregates and shall show satisfactory mixing properties when combined with the aggregates without balling up or becoming hard or tacky. The test for cracked material shall be made on the asphalt prior to emulsification.

Coating test shall not show appreciable separation when emulsified asphalt is mixed with washed, dry, clean stone for three (3) minutes. The emulsified asphalt shall coat the stone thoroughly.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility.

204-2.4 HYDRATED LIME. The hydrated lime shall meet the requirements of the A. S. T. M. Designation C-6.

204-2.5 PORTLAND CEMENT. The Portland cement shall meet the requirements of A. A. S. H. O. Specification M-85.

COMPOSITION OF MIXTURE

204-3.1 GRADATION AND COMPOSITION. The mineral aggregate for the base course shall be of such size that the percentage composition by weight, as determined by laboratory sieves will conform to one of the following gradations:

TABLE 2.—*Requirements for Gradation of Aggregate*

Sieve size	Percentage passing sieves (square openings)			
	A 1" maximum	B ¾" maximum	C ½" maximum	D No. 4 maximum
1 inch.....	100			
¾ inch.....	82-100	100		
½ inch.....	70- 90	82-100		
⅜ inch.....	60- 82	70- 90	82-100	100
No. 4.....	47- 70	55- 79	62- 88	92-100
No. 10.....	35- 60	40- 67	45- 75	80-100
No. 40.....	15- 40	17- 44	20- 48	65- 94
No. 80.....	8- 26	9- 29	10- 32	25- 65
No. 200.....	3- 8	3- 8	4- 9	10- 42
Bitumen, percent.....	3.5-6.0	3.5-6.5	4.0-7.0	5- 10 4.5-7.5

In Table 2 the percentages of bitumen are for stone and gravel aggregates. If the total aggregate is composed of slag, the percentages of bituminous material shown shall be increased by thirty (30) percent. Where only a part of the aggregate is slag, this increase shall be made in a corresponding proportion.

The gradations in this table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The gradations of the composite mix shall be within the limits designated in the table, shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The selection of any of the gradations shown in the table shall be such that the maximum size aggregate used in any course shall not be more than one-half the thickness of the layer of the course being constructed.

The range of bitumen shown in Table 2 represents the maximum and minimum amounts based on the actual bituminous agencies affecting the ultimate mix after evaporation or oxidation of fluxes. The exact amount for the job mix shall be fixed by laboratory tests and shall be subject to change as required by actual field conditions. The percentage of bituminous material shown is by weight of the dry aggregate.

When called for in the proposal Portland cement or lime shall be added to the emulsion mix to control the consistency or set of the mixture.

CONSTRUCTION METHODS

204-4.1 WEATHER LIMITATIONS. The base course shall be constructed and operations shall be carried on only when the surface is dry, when the atmospheric temperature is above 50° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

204-4.2 EQUIPMENT. (1) *General.* All methods employed in performing the work and all equipment, tools, other plant and machinery used for handling materials and executing any part of the work shall be subject to approval of the engineer before the work is started; and whenever found unsatisfactory, shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(2) *Traveling Plant Mixer.* The traveling plant shall be self-propelled or tractor drawn and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the subgrade or subbase course. The device for picking up the aggregates from the windrow shall be such that it will take up the loose material and leave the underlying course clean without damage. Plants equipped for drying the aggregates before adding the bituminous material shall be so constructed as not to allow a loss of mineral filler or segregation of the aggregate. The equipment for proportioning the aggregate and bituminous material shall accurately measure the specified amounts of material for the mix while the machine is in operation. The plant shall be capable of thoroughly combining the aggregates and bituminous material into a mixture of uniform color with all the particles completely coated and shall also be capable of depositing the processed mixture on the subgrade or subbase.

Other machines capable of accomplishing the required results both in regard to uniformity and depth in one pass will be acceptable under this specification.

Approved methods shall be provided for accurately controlling the correct amount of filler, Portland cement, or lime and for the induction of same into the mixture at the specified time when these materials are required.

(3) *Spreading Equipment.* Blade graders for windrowing aggregate and for spreading processed material shall be self-powered or

tractor drawn. The grader shall have a wheel base of not less than fifteen (15) feet, shall have a blade not less than ten (10) feet long, and be equipped with wheels of sufficient width to prevent excessive rutting.

If aeration is not necessary prior to compaction the mixed material may be placed and spread by a mechanical spreader and finisher.

(4) *Rolling Equipment.* (a) The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer. The weight of the roller shall be increased as the rolling progresses to the maximum degree obtainable without detrimental results to the course being compacted.

(b) The steel-wheel rollers shall be of the self-propelled tandem or three-wheel type weighing not less than five (5) tons and not more than ten (10) tons. The wheels on the roller shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking. The rollers shall be maintained in good condition and be operated by experienced rollermen.

204-4.3 PREPARATION OF UNDERLYING COURSE.

The underlying course upon which the base course is to be placed shall be properly prepared, smooth and fully compacted. It shall be cleaned of all loose material and deleterious matter and when tested with a sixteen (16) foot straightedge shall show no deviation in excess of three-eighths ($\frac{3}{8}$) inch.

204-4.4 PLACING MINERAL AGGREGATE. If borrow or foreign aggregate is used, it shall be transported to the site of paving in trucks equipped with pneumatic tires. Both speed and load shall be regulated by the engineer in order to reduce the possibility of damage to the existing surface. The aggregate existing or otherwise shall be formed in windrows in such quantity and proportions as to provide sufficient total aggregate, conforming with the specified gradation, to produce a finished base course of the specified compacted thickness. The contractor may proportion the amount of coarse aggregate and mineral filler in the windrow by weighing with suitable equipment or by using any other methods or devices which will be equally as effective as weighing equipment in placing the amount of total aggregate necessary to satisfy the yardage requirements for the area to be covered. After the proportions of coarse aggregate and mineral filler have been adjusted if required to meet the gradation, the total loose aggregate shall be thoroughly mixed to the satisfaction of the engineer. It shall then be bladed into windrows of uniform cross sections for the final measurement and sampling for grading adjustment. The formation of windrows in advance of mixing shall be limited so as to prevent

water from standing on the subgrade or ponding between windrows in case of rain.

Care shall be exercised to prevent the aggregate from becoming mixed with subgrade, subbase, or shoulder material. The uniform windrows shall be left undisturbed until measuring and sampling are completed.

204-4.5 MOISTURE CONTENT OF AGGREGATE. Immediately prior to bituminizing, the aggregate to be treated shall be tested for moisture. If the moisture content is in excess of the maximum allowable percentage the aggregate shall be turned by blades or disc harrows, or otherwise aerated, until the moisture content is reduced. The prepared aggregate shall then be uniformly windrowed as before or spread uniformly for mixing.

204-4.6 MIXING. The aggregate, windrowed and prepared as specified above, shall then be mixed with the bituminous material by means of the traveling mixing plant and deposited ready for spreading.

The Portland cement and lime shall be added during the mixing procedure at the time and in the amounts required by the engineer. These materials shall not be used in tar mixtures.

The quantity of bituminous material as calibrated for continuous mixer shall be determined by the engineer, and introduced into the mixer. The mixing shall continue for such period as is necessary to coat all of the particles and obtain a homogeneous mixture.

Before spreading, the mixture shall be examined by the engineer who shall determine whether the mixing is complete and satisfactory. Should the mixture show an excess, deficiency, or uneven distribution of bituminous material, the unsatisfactory condition shall be corrected by the addition of the required aggregate or bituminous material, and by remixing. If necessary, the material shall be harrowed or disced and all compressed masses of material broken up. No spreading shall be done, except when authorized by the engineer.

204-4.7 SPREADING AND FINISHING. (1) *General.* Spreading shall not be started until the subgrade or subbase has been properly prepared, compacted, and approved by the engineer.

When in-place materials or aggregates are used in the base course mixture, the coarse aggregate between the 2-inch sieve and the 1½-inch sieve shall not exceed five (5) percent. Any material that will not pass the 2½-inch sieve shall be culled out and removed from the base course.

Grade control between the edges of the runway shall be by means of grade stakes or steel grade pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between the stakes or pins.

When practicable and to protect the subgrade and to insure proper drainage, the mixing and spreading of the base shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

The base course shall not be placed in a layer thicker than four (4) inches compacted thickness. Each layer shall be spread, finished and compacted, as described herewith, before an additional layer is placed.

(2) *Spreading and Blade Finishing.* The mixture shall be placed in lanes parallel to the centerline of the runway and ending each days run for the full width of the lane.

After the mixing has been completed, the mixed material shall be spread to the required width and depth by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading from a windrow, care shall be taken to prevent cutting into the underlying course. If necessary to prevent such cutting, a layer of the mixture approximately one-half ($\frac{1}{2}$) inch thick shall be left at the bottom of the windrow. The mixture shall be spread and cured in thin layers. The surface shall be continually bladed, disced, and dragged if necessary until a smooth, uniform surface, true to line, grade and cross section has been developed. Should the mixture show an excess, deficiency, or uneven distribution of bituminous material, such unsatisfactory conditions shall be corrected.

After the base course material has been mixed, spreading shall not be started if threatening weather is apparent. The engineer shall have control of the spreading, aeration, and rolling procedures, and no spreading shall be done without his consent. The contractor shall regulate his operations in a scheduled manner by mixing only such amounts that can be spread, aerated, and compacted within relative short periods. Those areas which become wet shall be dried and remixed with bituminous material when directed. The remixing, including application of additional bituminous material where required, shall be handled in such manner as to insure thorough and uniform coating of the aggregate. Any mixture that is unsatisfactory because of becoming wet or remains unsatisfactory after remixing shall be removed. Prior to final compaction, the moisture content of the base material shall have been reduced by aeration to three and one-half ($3\frac{1}{2}$) percent or less.

204-4.8 COMPACTION OF MIXTURE. Aeration after mixing and prior to rolling shall be continued until the mixture is in suitable condition for proper compaction. After each layer has been placed and cured, it shall be thoroughly and uniformly compressed by rollers, as specified. Blading shall continue during the rolling only if so ordered by the engineer. Initial rolling shall be done with pneumatic rollers.

Initial rolling shall be done longitudinally, overlapping on successive trips by at least twelve (12) inches. Alternate trips of the roller shall be of slightly different lengths. Rolling shall continue until the surface is of uniform texture and degree of compaction and is true to grade and cross section. Final rolling shall be done with the tandem rollers. Rolling shall continue until a density is obtained which is at least ninety-five (95) percent of the maximum density obtainable on

the same mixture if compacted in a laboratory using the standard Proctor Method with all aggregate in the bituminous mixture passing the $\frac{1}{2}$ -inch mesh sieve. (Proctor Method, A. A. S. H. O. Method T-99 with mixture at a temperature of 140° F. placed in three layers with 25 blows per layer.)

The speed of the rollers shall at all times be slow enough to avoid displacement of the mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes and of fresh mixture where required. Sufficient rollers of the designated types shall be furnished to adequately handle the rate of spreading and aeration of the mixture.

Upon instructions from the engineer, the course shall be rerolled any time within two weeks after it is laid, and shall be subjected to diagonal rolling, crossing the lines of the first. If necessary to prevent adhesion of the mixture to the power roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be in good condition and shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with tampers. Such tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to acceptance, shall be removed and replaced, at the expense of the contractor, with fresh mixture which shall be compacted to conform with the surrounding area. Skin patching on an area that has been rolled shall not be allowed. Any mixture remaining unbonded after rolling shall be removed and replaced.

204-4.9 JOINTS. The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the previously placed base material for the full specified depth of the course. A straightedge shall be used across all joints to test and insure grade and contour of the surface.

204-4.10 SHAPING EDGES. While the base is being compacted and finished, the contractor shall trim the edges neatly to line.

204-4.11 SURFACE TESTS. The finished surface shall not vary more than three-eighths ($\frac{3}{8}$) inch for the base course when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the center line. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after

initial compression by powered rollers and any variation shall be corrected by removing or adding materials and continuing the rolling.

204-4.12 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by removing the base material, replacing the base mixture, rolling, reshaping, and finishing in accordance with these specifications. The contractor shall replace at his expense the base material where borings are taken for test purposes.

204-4.13 MAINTENANCE. The surface of the base course shall be maintained in its finished condition until any surface course or surface treatment provided in the contract is placed thereon, and the contract is completed and accepted.

204-4.14 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be accepted.

The contractor shall furnish vendor's certified test reports for each carload or equivalent of bituminous material shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

204-4.15 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of freight and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

204-5.1 The unit of measurement for base course laid shall be the square yard. The yardage to be paid for shall be the square yards of base course completed and accepted in accordance with the plans and specifications, or as directed by the engineer.

204-5.2 The unit of measurement for the bituminous material shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F. in accordance with A. S. T. M. Designation D-206 for asphalt materials, or with A. S. T. M. Designation D-633 for tar, or in accordance with appropriate formula or table for emulsified asphalt.

BASIS OF PAYMENT

204-6.1 The quantities of base mixture and bituminous material determined, as provided in 5.1 and 5.2 above, shall be paid for at the respective contract unit prices per square yard in the bid schedule for base course and per gallon or per ton for bituminous material, which prices and payment shall constitute full compensation for preparing subbase or subgrade; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas including remixing when necessary; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; for all labor, equipment, tools, and incidentals necessary to complete the item, except any prime coat or tack coat.

Payment will be made under:

- Item P-204-6.1 Mixed in-place Base Course—per square yard.
- Item P-204-6.1 Bituminous Material—per gallon.

ITEM P-205 DRY-BOUND MACADAM BASE COURSE

DESCRIPTION

205-1.1 This item shall consist of a base course composed of crushed stone or crushed slag, constructed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with the lines and grades established by the engineer.

MATERIALS

205-2.1 AGGREGATE. The coarse aggregate and screenings shall be either crushed stone or crushed slag.

The crushed stone shall consist of hard, durable particles or fragments of stone, free from an excess of flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter, and shall have a percent of wear of not more than 45 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed slag shall be air-cooled blast furnace slag, and shall consist of angular fragments, reasonably uniform in density and quality, and reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than sixty-five (65) pounds per cubic foot, and shall have a percent of wear of not more than 45 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subjected to five cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

Crushed stone and crushed slag for coarse aggregate and screenings shall meet the requirements for gradation given in Table 1, using A. A. S. H. O. Method T-27.

TABLE 1.—Requirements for Gradation of Aggregate

Sieve designation	Percentage by weight passing square mesh sieves	
	Coarse aggregate	Screenings
3-inch.....	100	-----
2½-inch.....	90-100	-----
1½-inch.....	25- 60	-----
¾-inch.....	0- 10	-----
⅝-inch.....	-----	100
No. 4.....	-----	85-100
No. 100.....	-----	10- 30

CONSTRUCTION METHODS

205-3.1 OPERATION AT SOURCES OF SUPPLY. All work involved in clearing and stripping of quarries and pits and handling unsuitable material encountered shall be performed by the contractor at his own expense. The base material shall be obtained from sources that have been approved. The material shall be handled in a manner that a uniform and satisfactory product shall be secured.

205-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good working condition and be operated by an experienced rollerman.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds, or consist of other approved spreading devices which will place the base aggregate or insulation material in uniform layer with a minimum of segregation.

The crushing plant and the screening plant shall be designed, constructed, and operated and of such capacity so as to produce a base course material of the gradation and fractions required.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure proper application when required for compacting the insulation course.

205-3.3 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled until firm before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the center line of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the subbase and to insure proper drainage, the spreading of the base shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

205-3.4 INSULATION COURSE. A layer of screenings or sand shall be spread uniformly upon the underlying course in the amount of not less than seventy-five (75) pounds per square yard unless otherwise specified in the proposal. The screenings or sand

shall be spread by methods similar to those required for spreading coarse aggregate and if necessary shall be shaped by road machine to the required section and smoothness. The layer shall then be rolled and watered until firmly compacted. The sand gradation shall be such that from five (5) to ten (10) percent shall pass the No. 200 mesh sieve.

205-3.5 SPREADING COARSE AGGREGATE. When the prepared underlying course is the insulation course, it shall be checked and accepted by the engineer before placing and spreading operations are started.

The coarse aggregate shall be spread uniformly and evenly upon the prepared course by the use of spreader boxes or other approved devices that shall spread the aggregate in the required amount so as to avoid or minimize the need for hand manipulation. Dumping from vehicles in piles or windrows so as to require rehandling will not be permitted. Hauling over the partly completed base course shall not be permitted.

The surface of the aggregate shall be carefully trued up and all high or low spots remedied by removing or adding aggregates as may be required. The course shall be lightly rolled, after which the surface shall again be tested and trued up if necessary. This operation shall be repeated until the uniform smooth surface is secured which, when tested with a sixteen (16) foot straightedge, shall be found to be free from high and low places.

The base course shall be constructed in a layer of not less than three (3) inches nor more than four (4) inches of compacted thickness. No segregation of large or fine particles will be allowed, and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine materials. Coarse aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling and application of screenings.

205-3.6 ROLLING. Immediately following the trueing of the spread coarse aggregate, it shall be compacted to the full width by rolling with a three-wheel power roller. Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels.

The rolling shall continue until the stone is thoroughly keyed, the interstices of the metal reduced to a minimum and creeping of the stone ahead of the roller no longer visible.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) inch when tested with a sixteen (16) foot straightedge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

205-3.7 APPLYING SCREENINGS. After the coarse aggregate has been thoroughly keyed and set by the rolling described, screenings in an amount that will completely fill the interstices shall be applied gradually and uniformly over the surface. Rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles on the coarse aggregate but shall be spread in thin layers.

The roller used shall meet the requirements specified above and be equipped with a broom of an approved type. The screenings shall be applied at a uniform and slow rate so as to insure filling of all voids. Hand brooms, where necessary, shall be used to sweep the screenings into unfilled voids and to distribute them. The spreading and rolling and brooming of screenings shall be performed on sections not to exceed 2,000 square yards, and shall continue until no more screenings can be forced into the voids of the coarse aggregate.

205-3.8 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straightedge applied to the surface parallel to the center line and at right angles.

205-3.9 RECONSTRUCTING MACADAM. Should the underlying course at any time become soft or churned up with the base course material or the shoulder material mixed with the base course material the contractor shall, without additional compensation, remove the mixture from the affected portion, reshape and compact the underlying course, and replace the removed section in accordance with the foregoing requirements.

205-3.10 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. Where the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by taking up the base material, removing and replacing with satisfactory materials properly laid, rolled, bonded, and finished in accordance with these specifications. The contractor shall replace at his expense the base material where borings are taken for test purposes.

205-3.11 MULTIPLE LAYERS. When it is necessary to construct the course in more than one layer to conform to the lines, grades, and cross-sections indicated on the plans, each layer shall be constructed as described above.

The surface of the base course shall be maintained in its finished condition until any surface course or pavement provided in the contract is placed thereon, and the contract is completed.

205-3.12 PROTECTION. Work on the stone base shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the stone or screenings contain frozen materials, or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when in his opinion such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

During the placing, spreading, and rolling of the insulation course, coarse aggregate and screenings, care shall be exercised to prevent the incorporation of subgrade or shoulder material into these macadam materials.

205-3.13 FREIGHT AND WEIGH BILLS. Before final estimate is allowed, the contractor shall file with the engineer receipted freight bills on all coarse aggregate and screenings as separate items where railroad shipments are made and certified weigh bills when the material is received by any other manner showing the actual tons that have been used in this item.

Copies of all freight bills and weigh bills shall be furnished the engineer during the progress of the work.

METHOD OF MEASUREMENT

205-4.1 The yardage of macadam base course to be paid for shall be the cubic yards of base course material including all screenings, bonded and accepted in the completed base course. Quantities of base course material and screenings shall be measured in final position based upon depth tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course or by means of average end areas on the completed work computed from elevations to the nearest 0.01 foot.

The depth of the base shall not include the insulation course. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as the specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment.

BASIS OF PAYMENT

205-5.1 The yardage of macadam base course measured as provided above shall be paid for at the contract unit price per cubic yard for macadam base course, which price and payment shall constitute

full compensation for furnishing, hauling, and placing the materials; for spreading and rolling; reconditioning the underlying course and shoulders; for placing, watering, and rolling insulation course; for reconstruction of damaged or deficient base; for maintenance of surface; for refilling test holes; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-205-5.1 Dry-bound Macadam Base Course—per cubic yard.

ITEM P-206 WATER-BOUND MACADAM BASE COURSE

DESCRIPTION

206-1.1 This item shall consist of a base course composed of crushed stone or crushed slag, water-bound, constructed on a prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with lines and grades established by the engineer.

MATERIALS

206-2.1 AGGREGATE. The coarse aggregate and screenings shall be either crushed stone or crushed slag.

The crushed stone shall consist of hard, durable, particles or fragments of stone free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter, and shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O., Method T-96 (Los Angeles Rattler Test).

The crushed slag shall be air-cooled blast furnace slag, and shall consist of angular fragments, reasonably uniform in density and quality, and reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than sixty-five (65) pounds per cubic foot, and shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O., Method T-96 (Los Angeles Rattler Test).

The crushed aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subjected to five cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

Crushed stone and crushed slag for coarse aggregate and screenings shall meet the requirements for gradation given in Table 1, using A. A. S. H. O. Method T-27.

TABLE 1.—Requirements for Gradation of Aggregate

Sieve designation	Percentage by weight passing square mesh sieves	
	Coarse aggregate	Screenings
3-inch.....	100	-----
2½-inch.....	90-100	-----
1½-inch.....	25- 60	-----
¾-inch.....	0- 10	-----
⅜-inch.....	-----	100
No. 4.....	-----	85-100
No. 100.....	-----	10- 30

CONSTRUCTION METHODS

206-3.1 OPERATION AT SOURCES OF SUPPLY. All work involved in clearing and stripping of quarries and pits and handling unsuitable material encountered shall be performed by the contractor at his own expense. The base material shall be obtained from sources that have been approved. The material shall be handled in a manner that a uniform and satisfactory product shall be secured.

206-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good working condition and be operated by an experienced rollerman.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds or consist of other approved spreading devices which will place the base aggregate or insulation material in a uniform layer with a minimum of segregation.

The crushing plant and the screening plant shall be designed, constructed, and operated and of such capacity so as to produce a base course material of the gradation and fractions required.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

206-3.3 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled until firm before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the center line of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the subgrade and to insure proper drainage, the spreading of the base shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

206-3.4 INSULATION COURSE. A layer of screenings or sand shall be spread uniformly upon the underlying course in the amount of not less than seventy-five (75) pounds per square yard unless otherwise specified in the proposal. The screenings or sand shall be spread by methods similar to those required for spreading coarse aggregate and, if necessary, shall be shaped by road machine

to the required section and smoothness. The layer shall then be rolled and watered until firmly compacted. The sand gradation shall be such that from five (5) to ten (10) percent shall pass the No. 200 mesh sieve.

206-3.5 SPREADING COARSE AGGREGATE. When the prepared underlying course is the insulation course, it shall be checked and accepted by the engineer before placing and spreading operations are started.

The coarse aggregate shall be spread uniformly and evenly upon the prepared course by the use of spreader boxes or other approved devices that shall spread the aggregate in the required amount so as to avoid or minimize the need for hand manipulation. Dumping from vehicles in piles or windows so as to require rehandling will not be permitted. Hauling over the partly completed base course shall not be permitted.

The surface of the aggregate shall be carefully trued up and all high or low spots remedied by removing or adding aggregate as may be required. The course shall be lightly rolled, after which the surface shall again be tested and trued up if necessary. This operation shall be repeated until a uniform smooth surface is secured which, when tested with a sixteen (16) foot straightedge, shall be found to be free from high and low places.

The base course shall be constructed in a layer of not less than three (3) inches nor more than four (4) inches of compacted thickness. Each layer shall be tested by depth blocks. No segregation of large or fine particles will be allowed, and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine materials. Coarse aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling and application of screenings.

206-3.6 ROLLING. Immediately following the truing of the spread coarse aggregate, it shall be compacted to the full width by rolling with a three-wheel power roller. Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. The rolling shall continue until the stone is thoroughly keyed, the interstices of the metal reduced to a minimum, and creeping of the stone ahead of the roller no longer visible.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) inch when tested with a sixteen (16) foot straightedge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand

tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

206-3.7 APPLYING SCREENINGS. After the coarse aggregate has been thoroughly keyed and set by the rolling described, screenings in an amount that will completely fill the interstices shall be applied gradually over the surface. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles on the coarse aggregate but shall be spread in thin layers.

The roller used shall meet the requirements specified above and be equipped with a broom of an approved type. The screenings shall be applied at a uniform and slow rate so as to insure filling of all voids. Hand brooms, where necessary, shall be used to sweep the screenings into unfilled voids and to distribute them. The spreading and rolling and brooming of screenings shall be performed on sections not to exceed 2,000 square yards, and shall continue until no more screenings can be forced into the voids of the coarse aggregate when the screenings are dry.

206-3.8 SPRINKLING. Immediately after the voids of a section of the course have been filled with screenings the macadam shall be sprinkled, the sprinkler being followed by the roller. All excess screenings forming in piles or cakes on the surface shall be scattered by light sweepings. The sprinkling and rolling shall continue and additional screenings applied where necessary until all voids are completely filled and the coarse stone firmly set and bonded. The quantity of screenings and water necessary, determined by the engineer, shall be sufficient to completely fill and bond the entire depth of the layer of the coarse aggregate and to produce a granular surface.

206-3.9 SURFACE TEST. After the course is complete the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straightedge applied to the surface parallel to the center line and at right angles.

206-3.10 RECONSTRUCTING MACADAM. Should the underlying course at any time become soft or churned up with the base course material or the shoulder material mixed with the base course material the contractor shall, without additional compensation, remove the mixture from the affected portion, reshape and compact the underlying course, and replace the removed section in accordance with the foregoing requirements.

206-3.11 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. Where

the base deficiency is more than one-half ($\frac{1}{2}$) inch the contractor shall correct such areas by taking up the base material, removing and replacing with satisfactory materials properly laid, rolled, bonded, and finished in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

206-3.12 MULTIPLE LAYERS. When it is necessary to construct the course in more than one layer to conform to the lines, grades, and cross sections indicated on the plans, each layer shall be constructed as described above.

The surface of the base course shall be maintained in its finished condition until any surface course or pavement provided in the contract is placed thereon, and the contract is completed.

206-3.13 PROTECTION. Work on the stone base shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the stone or screenings contain frozen materials or the underlying course is frozen the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

During the placing, spreading, and rolling of the insulation course, coarse aggregate and screenings, care shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material into these macadam materials.

206-3.14 FREIGHT AND WEIGH BILLS. Before final estimate is allowed, the contractor shall file with the engineer receipted freight bills on all coarse aggregate and screenings as separate items where railroad shipments are made, and certified weigh bills when the material is received by any other manner, showing the actual tons that have been used in this item.

Copies of all freight bills and weigh bills shall be furnished the engineer during the progress of the work.

METHOD OF MEASUREMENT

206-4.1 The yardage of macadam base course to be paid for shall be the cubic yards of base course material including all screenings, bonded and accepted in the completed base course. Quantities of base course material and screenings shall be measured in final position based upon depth tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the completed work computed from elevations to the nearest 0.01 foot.

The depth of the base shall not include the insulation course. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as the specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment.

BASIS OF PAYMENT

206-5.1 The yardage of macadam base course measured as provided above shall be paid for at the contract unit price per cubic yard for macadam base course, which price and payment shall constitute full compensation for furnishing, hauling, and placing the materials; for spreading, sprinkling, and rolling; for reconditioning the underlying course and shoulders; for placing, watering, and rolling insulation course; for reconstruction of damaged or deficient base; for maintenance of surface; for refilling test holes; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-206-5.1 Water Bound Macadam Base Course—per cubic yard.

ITEM P-208 AGGREGATE BASE COURSE

DESCRIPTION

208-1.1 This item shall consist of a base course composed of crushed or uncrushed coarse aggregate, bonded with either soil or fine aggregate or both, constructed on a prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

MATERIALS

I. Uncrushed Coarse Aggregate:

208-2.1 MATERIALS. The base course material shall consist of hard, durable particles or fragments of stone or gravel mixed or blended with sand, clay, stone dust, or other similar binding or filler materials produced from approved sources to provide a uniform mixture complying with the requirements of these specifications as to gradation, soil constants, and capability of being compacted into a dense and well-bonded base. All oversize pebbles, stones, rock, and boulders occurring in the pit or quarry material shall be screened out or removed and wasted; those of acceptable quality may be crushed and become a part of the base material, provided the blend meets the specified gradations. The aggregate shall be free from vegetable matter, loam, lumps or excessive amounts of clay and other objectionable or foreign substances. The coarse aggregate shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

II. Crushed Coarse Aggregate:

208-2.2 MATERIALS. The aggregates shall consist of both fine and coarse fragments of crushed stone, crushed slag, or crushed gravel, blended if required, with soil, sand, screenings, or other similar approved materials. The completed mixture of aggregates shall be capable of being compacted into a dense and well-bonded base.

The crushed stone shall consist of hard, durable particles or fragments of stone, free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter, and shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed slag shall be air-cooled blast furnace slag and shall consist of angular fragments, reasonably uniform in density and

quality, and reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than seventy (70) pounds per cubic foot and shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed gravel shall consist of hard, durable stones, rock, and boulders of accepted quality crushed to specified size, and shall be free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter. The method used in production of crushed gravel shall be such that the percentage of fractured particles occurring in the finished product shall be as nearly constant and uniform as practicable. The crushing of the gravel shall result in a product that at least sixty (60) percent of the material passing a 2-inch sieve and retained on a 1-inch sieve; that at least sixty (60) percent of the material passing a 1-inch sieve and retained on a $\frac{3}{4}$ -inch sieve, and that at least sixty (60) percent of the material passing a $\frac{3}{4}$ -inch sieve and retained on a No. 4 mesh sieve will have at least one fractured face. If necessary to meet this requirement or to eliminate an excess of fine, uncrushed particles the gravel shall be screened before crushing. All stones, rocks, and boulders of inferior quality occurring in the pit shall be separated out and wasted. The gravel shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

All material passing the No. 4 mesh sieve produced in the crushing operation of either the stone, slag, or gravel shall be incorporated in the base material unless there is an excessive amount which, if included, would not meet the gradation requirements.

III. Requirements Applying to I and II:

208-2.3 GRADATION. The gradation of the processed or unprocessed material shall meet the requirements of one of the gradations given in the table below using A. A. S. H. O. Methods T-11 and T-27.

TABLE 1.—Requirements for Gradation of Aggregate

Sieve designation	Percentage by weight passing square openings		
	A	B	C
	2" maximum	1½" maximum	1" maximum
2-inch	100	100	100
1½-inch		100	
1-inch	55-85	70-95	100
¾-inch	50-80	55-85	70-100
No. 4	30-60	30-60	35-65
No. 40	10-30	10-30	15-30
No. 200	5-15	5-15	5-15

The gradations in the table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The final gradations decided on within the limits designated in the table shall be uniformly graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one-half the fraction passing the No. 40 mesh sieve.

The portion of the filler and binder, including any blended material, passing the No. 40 mesh sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with A. A. S. H. O. Methods T-89, T-90, and T-91. The modification of Test Method T-87 is given under paragraph 2.4, included below. When the modified test T-87 as included is used in preparing the sample, the plasticity index may be increased up to but not exceeding 8.

The selection of any of the gradations shown in the table shall be such that the maximum size aggregate used in any course shall not be more than two-thirds the thickness of the layer of the course being constructed.

208-2.4 MODIFICATION OF TEST METHOD T-87. In the preparation of soil binder, the total sample shall first be dried in the air or in an oven at a temperature not to exceed 140° F. After dry screening out all material that will readily pass the No. 40 mesh sieve, the retained portion of the aggregate sample shall be immersed in a pan of clear water until all binder material has slaked down or disintegrated, which may require up to 72 hours. A shorter slaking time may be used provided the results are consistent with those obtained in a 72-hour slaking.

The slaked material shall then be washed over a No. 40 mesh sieve, care being taken that all lumps are broken down. After the sample has been wet screened, the pan containing the soil binder in the water shall be set aside and allowed to settle. The clear water shall then be siphoned or drawn off and the binder sample shall be dried at a temperature not to exceed 140° F. That portion of the soil binder secured in the slaking process, when dried, shall, if necessary, be repulverized with a rubber-covered pestle and mortar so that all particles will pass the No. 40 mesh sieve. This portion of the soil binder shall then be combined and thoroughly mixed with the portion of the soil binder obtained by dry screening, and soil constants shall be run upon this composite material.

208-2.5 FILLER FOR BLENDING. If filler, in addition to that naturally present in the base course material, is necessary for satisfactory bonding of the material, for changing the soil constants of the material passing the No. 40 mesh sieve, or for correcting the gradation to the limitations of the specified gradation, it shall be uniformly blended with the base course material on the runway, at the crushing plant, or at the mixing plant. The material for such

purpose shall be obtained from sources approved by the engineer and shall be of a gradation as necessary to accomplish the specified gradation in the finally processed material.

The additional filler may be composed of sand but the amount of sand shall not exceed twenty (20) percent by weight of the total combined base aggregate. The sand shall all pass a No. 4 mesh sieve and not more than five (5) percent by weight shall pass a No. 200 mesh sieve.

CONSTRUCTION METHODS

208-3.1 OPERATIONS IN PITS AND QUARRIES. All work involved in clearing and stripping pits and quarries including handling unsuitable material encountered shall be performed by the contractor. The contractor shall notify the engineer sufficiently in advance of the opening of any designated pit to permit staking of boundaries of the site and taking of elevations and measurements of the ground surface before any material is disturbed. The pits as utilized shall immediately be opened up so as to expose the vertical faces of the various strata of acceptable material and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all the exposed strata. All material shall be handled in a manner that a uniform and satisfactory base product shall be secured. The base course material shall be obtained from sources that have been approved.

208-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear-wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good condition and be operated by an experienced rollerman.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course, upon approval of the engineer. Such equipment shall be routed over the area being compacted, and shall be operated until the required density is obtained.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds, or of other approved spreading devices, which will place the base material in a uniform layer with a minimum of segregation.

Road machines shall weigh not less than three (3) tons and shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers.

Provision shall be made by the contractor for furnishing water at the plant or at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The crushing and screening plant or the mixing plant shall be designed, constructed, operated and of such capacity so as to thoroughly blend all the fractions and to mix these with water in the proportions as directed to produce a base course material of the gradation and consistency required. If a traveling plant is used, it shall be self-propelled or tractor-drawn and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the underlying course. The device for picking up the aggregates to be mixed shall be such that it will take up the loose material and leave the underlying course clean without damage.

208-3.3 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the center line of the runway and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course, and to insure proper drainage, the spreading of the base shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

208-3.4 METHODS OF PRODUCTION. (a) *Plant Mix.* When provided for in the proposal, or when selected by the contractor and approved by the engineer, the base material shall be uniformly blended or mixed in an approved plant. The mixing plant shall include bins for storage and batching of the aggregate, pump and tanks for water, and batch mixers of either the pugmill or drum type. All mineral aggregates shall be batched into the mixer by weight. The agitation shall be such that thorough dispersion of moisture is obtained. The size of the batch and the time of mixing shall be fixed by the engineer and shall produce the results and requirements specified. The base course material produced by combining two or more materials from different sources shall be mixed in a mixing plant described herein. The mixed material shall be at a satisfactory moisture content to obtain maximum density.

(b) *Travel Plant.* When the use of a traveling plant is allowed, the plant shall blend and mix the materials to meet these specifica-

tions. It shall accomplish thorough mixing in one trip. The agitation shall be such that the dispersion of the moisture is complete. The machine shall move at a uniform rate of speed and this speed shall be regulated to fix the mixing time. If a windrow-type of travel plant is employed for mixing, the aggregate shall be placed in windrows parallel to the pavement centerline. The windrow volume shall be sufficient to cover exact areas as planned. The windrow contents shall produce a mixture of the required gradation and bonding qualities. If a travel plant is used which is of the type that mixes previously spread aggregates in-place, the material shall have been spread in-place of such thickness and proportions as may be handled by the machine and to develop a base course of the thickness of each layer and of the gradations required. With either type of equipment, the mixed material shall be at a satisfactory moisture content to obtain the maximum density.

(c) *Proportioning or Blending In-Place.* When the base materials are to be proportioned and mixed or blended in-place, the different layers shall be placed and spread with the relative proportions of the components of the mixture being as designated by the engineer. The base aggregate shall be deposited and spread evenly to a uniform thickness and width. Then the binder or filler shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the engineer may direct to obtain the required gradation and layer thickness. When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary tillers, or a machine capable of combining these operations, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniform throughout and accepted by the engineer. Areas of segregated material shall be corrected by the addition of needed material and by remixing. Water shall be uniformly applied prior and during the mixing operation if necessary to maintain the material at the proper moisture content. When the mixing and blending has been completed, the material shall be bladed and dragged, if necessary, until a smooth uniform surface is obtained, true to line and grade.

(d) *Materials of Proper Gradation.* When the entire base course material from coarse to fine is secured in a uniform and well-graded condition and contains approximately the proper moisture, such approved material may be handled directly to the spreading equipment for placing. The material may be obtained from gravel pits, stock piles, or be produced from a crushing and screening plant with the proper blending. The materials from these sources shall meet the requirements for gradation, quality, and consistency. It is the intent of this section of the specifications of securing materials that will not require further mixing. The base material shall be at a satisfactory moisture content to obtain maximum density. Any minor deficiency or excess of moisture may be corrected by surface sprinkling or by aeration. In such instances some mixing or manipulation may be re-

quired immediately preceding the rolling to obtain the required moisture content. The final operation shall be blading or dragging if necessary to obtain a smooth uniform surface true to line and grade.

208-3.5 METHODS OF SPREADING. (a) The aggregate base material that is correctly proportioned, or has been processed in a plant, shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The base aggregate shall be spread by the use of spreader boxes or other approved devices that shall spread the aggregate in the required amount so as to avoid or minimize the need for hand manipulation. The spreader boxes or other devices shall be equipped to secure the required thickness of the material. Dumping from vehicles in piles so as to require rehandling will not be permitted. Hauling over the uncompacted base course shall not be permitted.

(b) The aggregate base material that has been processed in a traveling plant, or mixed and blended in-place, shall be spread in a uniform layer of required depth and width and to the typical cross section. The spreading shall be by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading, care shall be taken to prevent cutting into the underlying layer. The material shall be bladed and dragged if necessary until a smooth, uniform surface is obtained, true to line and grade.

(c) The base course shall be constructed in a layer of not less than two and one-half ($2\frac{1}{2}$) inches nor more than four and one-half ($4\frac{1}{2}$) inches of compacted thickness. Each layer shall be tested by depth blocks. The aggregate as spread shall be of uniform grading with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within these limits. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

The engineer will make tests to determine the maximum density and the proper moisture content of the base material, and this information will be available to the contractor. The base material shall be at a satisfactory moisture content when rolling is started and any minor variation shall be corrected by sprinkling or by aeration if necessary.

During the mixing and spreading process, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

208-3.6 FINISHING AND COMPACTING. After spreading, the aggregate shall be thoroughly compacted by rolling and sprinkling when necessary. The initial rolling of the course shall be done with suitable three-wheeled, ten-ton rollers or other approved equipment. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. The rolling shall continue until the aggregate is thoroughly set, the interstices of the metal reduced to a minimum, and creeping of the material ahead of the roller no longer visible. Rolling shall continue until the base material has been compacted to not less than 95 percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, and uniformly compacted base. For final rolling either ten-ton three-wheeled or eight-ton tandem rollers may be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened, then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer.

208-3.7 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown and, if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straight-edge applied to the surface parallel to the centerline and at right angles.

208-3.8 THICKNESS. The thickness of the base course shall be determined by depth tests of cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying, adding satisfactory base mixture,

rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

208-3.9 PROTECTION. Work on the base course shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the aggregates contain frozen materials or the underlying course is frozen the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when in his opinion such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

208-3.10 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping is completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The base shall be properly drained at all times. During this maintenance period, any deficiencies in thickness, composition, smoothness, or density shall be corrected in a satisfactory manner.

Before preparations have been started for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of binder. If during the curing period the surface of the base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

208-4.1 The quantity of aggregate base course either crushed or uncrushed as required in the proposal to be paid for shall be the number of cubic yards of base course material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position based upon depth tests, or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half inch in excess of that shown on the plans shall

be considered as specified thickness plus one-half inch in computing the yardage for payment. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

208-5.1 The quantity of aggregate base course measured, as provided above, shall be paid for at the contract unit price bid per cubic yard in the bid schedule for aggregate base course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the materials; for mixing, blading, sprinkling, shaping, and compacting; for reconditioning the underlying course and shoulders; for reconstruction of irregular surface or deficient thickness, and for maintenance; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit or quarry moves; for clearing, stripping, drainage, and clean-up of pits; for the handling and disposal of unsuitable materials encountered in pit or quarry operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-208-5.1 Uncrushed Aggregate Base Course—per cubic yard.

Item P-208-5.1 Crushed Aggregate Base Course—per cubic yard.

ITEM P-209 CRUSHED AGGREGATE BASE COURSE

DESCRIPTION

209-1.1 This item shall consist of a base course composed of crushed aggregates, constructed on the prepared underlying course in accordance with these specifications, and in conformity with the dimensions and typical cross section shown on the plans, and with the lines and grades established by the engineer.

MATERIALS

209-2.1 AGGREGATE. The aggregate shall be either crushed stone, crushed gravel, or crushed slag. The fine aggregate shall be screenings obtained from crushing stone, or gravel, or slag. Sand may be used as filler, but shall not exceed fifteen (15) percent by weight of the total combined aggregates.

The crushed stone shall consist of hard, durable particles or fragments of stone, free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter, and shall have a percent of wear of not more than 45 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed gravel shall consist of hard, durable stones, rock, and boulders of accepted quality crushed to specified sizes, and shall be free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter. The method used in production of crushed gravel shall be such that the finished product shall be as uniform as practicable. The crushing of the gravel shall result in a product that one hundred (100) percent of the material particles will have at least one fractured face. If necessary to meet this requirement, or to eliminate an excess of fine particles, the gravel shall be screened before crushing. All stones, rock, and boulders of inferior quality occurring in the pit shall be separated out and wasted. The gravel shall have a percent of wear of not more than 45 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed slag shall be air-cooled blast furnace slag, and shall consist of angular fragments, reasonably uniform in density and quality, and reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than seventy (70) pounds per cubic foot, and shall have a percent of wear of not more than 45 at 500 revolutions, as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed aggregate shall not show evidence of disintegration nor show a total loss greater than twelve (12) percent when sub-

jected to five cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

All material passing the No. 4 mesh sieve produced in the crushing operation of either the stone, gravel, or slag, shall be incorporated in the base material unless there is an excessive amount which, if included, would not meet the gradation requirements.

The crushed aggregate shall meet the requirements of one of the gradations given in the following table, using A. A. S. H. O. Methods T-11 and T-27.

TABLE 1.—*Requirements for Gradation of Aggregate*

Sieve designation	Percentage by weight passing square openings		
	A 2" maximum	B 1½" maximum	C 1" maximum
2-inch.....	100		
1½-inch.....		100	
1-inch.....	55- 85	70- 95	100
¾-inch.....	50- 80	55- 85	70-100
No. 4.....	30- 60	30- 60	35- 65
No. 40.....	10- 25	10- 25	15- 25
No. 200.....	3- 10	3- 10	3- 10

The gradations in the table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The final gradations decided on within the limits designated in the table shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one-half the fraction passing the No. 40 mesh sieve.

The portion of the base aggregate, including any blended material, passing the No. 40 mesh sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with A. A. S. H. O. Methods T-89, T-90, and T-91.

The selection of any of the gradations shown in the table shall be such that the maximum size aggregate used in any course shall not be more than two-thirds the thickness of the layer of course being constructed.

209-2.2 ADDITIONAL FINE MATERIAL. If additional fine material, in excess to that naturally present in the base course material, is necessary for correcting the gradation to the limitations of the specified gradation, for the satisfactory bonding of the base material, or for changing the soil constants of the material passing the No. 40 mesh sieve, it shall be uniformly blended and mixed with the base course material at the crushing plant or by an approved plant.

The additional fine material for this purpose shall primarily be obtained from the crushing of stone, gravel, or slag, and when used shall be of a gradation as necessary to accomplish the specified gradation in the finally mixed base course material.

The additional fine material may be composed of sand, but the amount of sand shall not exceed fifteen (15) percent by weight of the total combined base aggregate. The sand shall all pass a No. 4 mesh sieve and not more than five (5) percent by weight shall pass a No. 200 mesh sieve.

CONSTRUCTION METHODS

209-3.1 OPERATION AT SOURCES OF SUPPLY. All work involved in clearing and stripping of quarries and pits including handling unsuitable material encountered shall be performed by the contractor at his own expense. The base material shall be obtained from sources that have been approved. The material shall be handled in a manner that a uniform and satisfactory product shall be secured.

209-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear-wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good condition and be operated by an experienced rollerman.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course, upon approval of the engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds, or of other approved spreading devices, which will place the base material in a uniform layer with a minimum of segregation.

Provision shall be made by the contractor for furnishing water at the plant or at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The crushing plant and the mixing plant shall be designed, constructed, and operated of such capacity so as to thoroughly blend all the fractions, and to mix these with water in the proportions as directed, to produce a base course material of the gradation and consistency required. If a travelling plant is used, it shall be self-propelled or tractor-drawn and capable of maintaining a uniform rate

of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the underlying course. The device for picking up the crushed aggregates shall be such that it will take up the loose material and leave the underlying course clean without damage.

209-3.3 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

209-3.4 PLANT MIX. The base material shall be uniformly blended during crushing operations or mixed in an approved plant. The type of plant may be either a central proportioning and mixing plant or a traveling plant. The plant shall blend and mix the materials to meet these specifications and to the proper moisture content for compaction.

209-3.5 PLACING AND SPREADING. (a) *Central Plant.* The crushed aggregate base material that has been proportioned in a crushing and screening plant or proportioned and processed in a central mixing plant shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The base aggregate shall be spread by the use of spreader boxes or other approved devices or methods that shall spread the aggregate in the required amount in such a manner to avoid or minimize the need for rehandling the material and to prevent the rutting of the underlying course. The spreader boxes or other devices shall be equipped with strike-off templates or screeds that can be adjusted or controlled to secure the required thickness of the material. Dumping from vehicles in piles on the underlying course so as to require rehandling will not be permitted. Hauling over the uncompacted base course shall not be permitted.

(b) *Traveling Plant.* If a traveling plant method is used for mixing, the base material shall be placed on the underlying course in such condition as to provide a base mixture conforming to the

specified gradation and moisture content, and in such quantity as to develop the thickness of the layer of the base and the density after compaction. The material shall be shaped to a uniform section. The mixture shall be examined by the engineer who shall determine whether the mixing is complete and satisfactory, and whether the proper moisture content is maintained before compaction is started. No spreading shall be done except when authorized. Care shall be taken that no material from the underlying course is mixed with the base material. The base course shall be bladed, disced, and dragged if necessary until a smooth, uniform, surface is obtained, true to line, grade, and cross section and the mix is in condition for compacting.

(c) *Method of Placing.* The base course shall be constructed in a layer of not less than two and one-half ($2\frac{1}{2}$) inches nor more than four and one-half ($4\frac{1}{2}$) inches of compacted thickness. Each layer shall be tested by depth blocks. The aggregate as spread shall be of uniform gradation with no segregation or pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within these limits. No material shall be placed in snow or on a soft, muddy, or frozen subbase, or underlying course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

The engineer will make tests to determine the maximum density and the proper moisture content of the base material, and this information will be available to the contractor. The base material shall be at a satisfactory moisture content when rolling is started, and any minor variations shall be corrected by sprinkling or by aeration if necessary.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

209-3.6 FINISHING AND COMPACTING. After spreading, the crushed aggregate shall be thoroughly compacted by rolling and sprinkling when necessary. The initial rolling of the course shall be done with a suitable three-wheeled roller or other approved equipment. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. The rolling shall continue until the stone is thoroughly set, the interstices of the material reduced to a minimum, and creeping of the stone ahead of the roller no longer visible. Rolling shall continue until the base material has been compacted to not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as

required or directed to obtain a smooth, even, and uniformly compacted base. For final rolling either ten (10) ton three-wheel or eight (8) ton tandem rollers may be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wave-like motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened, then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer.

209-3.7 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown, and, if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straightedge applied to the surface parallel to the centerline and at right angles.

209-3.8 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) of an inch, the contractor shall correct such areas by scarifying, adding satisfactory base mixture, rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

209-3.9 PROTECTION. Work on the base course shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the aggregates contain frozen materials or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

209-3.10 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until

such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping is completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The base shall be properly drained at all times. During this maintenance period, any deficiencies in thickness, composition, smoothness, or density shall be corrected in a satisfactory manner.

Before preparations have been started for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of binder. If, during the curing period, the surface of the base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course to be paid for shall be the number of cubic yards of material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position, based upon depth tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment.

BASIS OF PAYMENT

209-5.1 The quantity of crushed aggregate base course as provided above shall be paid for at the contract unit price bid per cubic yard in the bid schedule for crushed aggregate base course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the materials; for mixing, blading, sprinkling, shaping, and compacting; for reconditioning the underlying course and shoulders; for reconstruction of irregular surface, or deficient thickness, and for maintenance; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit or quarry moves; for clearing, stripping, drainage, and clean-up of pits; for the handling and disposal of unsuitable materials encountered in pit or quarry operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-209-5.1 Crushed Aggregate Base Course—per cubic yard.

ITEM P-210 CALICHE BASE COURSE

DESCRIPTION

210-1.1 This item shall consist of a base course composed of caliche, caliche-gravel, caliche and limestone, or material of similar characteristics, constructed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

MATERIALS

210-2.1 MATERIALS. The base course material shall consist of caliche, caliche-gravel, caliche-limestone, or similar materials obtained from sources that have been approved by the engineer prior to use of the materials. All acceptable material shall be screened and the oversize shall be crushed and returned to the screened material in such manner and proportions that a uniform product will be produced.

The gradation of the material, as finally processed and blended, shall meet the following requirements using A. A. S. H. O. Methods T-11 and T-27:

Sieve designation	Percent by weight passing square mesh sieves
2-inch.....	100
No. 40.....	15-35
No. 200.....	0-15

That portion of the material, including the blended filler, passing a No. 40 mesh sieve, shall be known as soil binder and shall have a liquid limit of not more than 35 and a plasticity index of not more than 10 as determined by A. A. S. H. O. Methods T-89 and T-91, respectively, and T-87 modified as outlined below.

If necessary, the contractor will be required to blend or combine materials so that the finally processed material meets all of the requirements of these specifications. The contractor will be required to make such modifications in materials and methods as are necessary to secure a material which is capable of being compacted into a dense and well-bonded base.

210-2.2 MODIFICATION OF TEST METHOD T-87. In the preparation of soil binder, the total sample shall first be dried in the air or in an oven at a temperature not to exceed 140° F. After dry screening out all material that will readily pass the No. 40 mesh sieve, the retained portion of the aggregate sample shall be immersed in a pan of clear water until all binder material has slaked down or disintegrated, which may require up to seventy-two (72) hours. A shorter slaking time may be used provided the results are consistent with those obtained in a seventy-two (72) hour slaking.

The slaked material shall then be washed over a No. 40 mesh sieve, care being taken that all lumps are broken down. After the sample has been wet screened, the pan containing the soil binder in the water shall be set aside and allowed to settle. The clear water shall then be siphoned or drawn off and the binder sample shall be dried at a temperature not to exceed 140° F. That portion of the soil binder secured in the slaking process when dried shall, if necessary, be repulverized with a rubber-covered pestle and mortar so that all particles will pass the No. 40 mesh sieve and this portion of the soil binder shall then be combined and thoroughly mixed with the portion of the soil binder obtained by dry screening, and soil constants shall be run upon this composite material.

210-2.3 FILLER FOR BLENDING. If filler, in addition to that naturally present in the base course material, is necessary for satisfactory bonding of the material, for changing the soil constants of the material passing the No. 40 mesh sieve, or for correcting the gradation to the limitations of the specified gradation, it shall be uniformly blended with the base course material on the runway, at the crushing plant, or at the mixing plant. The material for such purpose shall be obtained from sources approved by the engineer and shall be of a gradation as necessary to accomplish the specified gradation in the finally processed material.

CONSTRUCTION METHODS

210-3.1 OPERATIONS IN PITS. All work involved in clearing and stripping pits including handling unsuitable material encountered shall be performed by the contractor. The contractor shall notify the engineer sufficiently in advance of the opening of any designated pit to permit staking of boundaries of the site and taking of elevations and measurements of the ground surface before any material is disturbed. The pits as utilized shall immediately be opened up so as to expose the vertical faces of the various strata of acceptable material and, unless otherwise directed, the material shall be secured in successive vertical cuts extending through all the exposed strata in order that a uniform material will be secured.

210-3.2 EQUIPMENT. All equipment necessary for the proper construction of the work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear-wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good condition and be operated by an experienced rollerman.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

The tamping roller shall consist of one or more units. Each unit shall consist of a watertight cylindrical drum not less than forty-eight (48) inches in length and shall be surmounted by metal studs with tamping feet projecting not less than seven (7) inches from the surface of the drum and spaced not less than six (6) inches nor more than ten (10) inches measured diagonally from center to center. The area of each tamper foot shall be not less than four (4) square inches nor more than twelve (12) square inches. Each unit shall be provided with a suitable tamper foot-cleaning device. Where more than one rolling unit is used, the rolling units shall be pivoted on the main frame in a manner which will permit the rolling units to adapt themselves to uneven ground surfaces and to rotate independently. When empty the roller shall weigh at least 120 pounds per square inch of area of tamping feet in contact with the ground. The maximum weight shall be such that the required densities are obtained. The roller and the operating tractor shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course upon approval of the engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Road machines shall weigh not less than three (3) tons and shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers.

Provision shall be made by the contractor for furnishing water at the plant or at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds, or other approved spreading devices, which will place the base material in a uniform layer with a minimum of segregation.

The traveling plant shall be designed, constructed, operated, and of such capacity so as to thoroughly mix all materials and water in the proportions as directed to produce a base course of the gradation and consistency required. The traveling plant shall be self-propelled or tractor-drawn and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the underlying course. The device for picking up the crushed aggregate from

the window shall be such that it will take up the loose material and leave the underlying course clean without damage.

210-3.3 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the center line of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

210-3.4 PLACING AND SPREADING. (a) The aggregate base material that has been proportioned or processed shall be placed on the prepared underlying course and compacted in layers to the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The base aggregate shall be spread by the use of spreader boxes or other approved devices that shall spread the aggregate in the required amount. The base material shall be spread and shaped the same day as placed.

(b) If travel-plant method is used for mixing, the base material shall be placed on the underlying course in windrows parallel to the centerline of the runway. Sufficient quantity and proportions of materials shall be placed in the windrow to provide a base mixture conforming to the specified grading and compacted thickness. The windrow shall be shaped to a uniform section and left undisturbed until measuring and sampling are complete. After mixing and before spreading, the mixture shall be examined by the engineer, who shall determine whether the mixing is complete and satisfactory and whether the proper moisture content is maintained for spreading. No spreading shall be done, except when authorized.

After the mixing has been completed, the base material shall be spread to the required depth and width by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading, care shall be taken to prevent cutting into the underlying layer. The material shall be bladed, disced, and dragged if necessary until a smooth, uniform, surface is obtained true to line, grade, and cross section, and in condition for compacting.

(c) When the base materials are to be proportioned and mixed or blended in-place, the different layers shall be spread and placed in the

following manner, the relative proportions of the components of the mixture being as designated by the engineer.

The base aggregate shall be deposited and spread evenly to a uniform thickness and width. Then the binder or filler or other admixture shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the engineer may direct to obtain the required base mixture.

When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary-tillers, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniform throughout. Areas of segregated material shall be corrected by the addition of binder or filler material and by thorough remixing. Water in the amount and as directed by the engineer shall be uniformly applied, prior to and during the mixing operations if necessary, to maintain the material at the proper moisture content. When the mixing and blending has been completed, the material shall be spread in a uniform layer which when compacted will meet the requirements of thickness and typical cross section. Hauling over material that has not been mixed and shaped will not be permitted except when necessitated by the placing of successive layers of materials. Layers of base material allowed to become partially compacted shall be scarified and disced before placing binder material or before blading and shaping for rolling.

(d) The base course shall be constructed in a layer of not less than three (3) inches nor more than six (6) inches of compacted thickness. Each layer shall be tested by depth blocks. The aggregate as spread shall be of uniform grading with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within these limits. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

The engineer will make tests to determine the maximum density and the proper moisture content of the base material, and this information will be available to the contractor. The base material shall be at a satisfactory moisture content when rolling is started and any minor variation shall be corrected by sprinkling or by aeration, if necessary.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

210-3.5 FINISHING AND COMPACTING. After spreading or mixing, the aggregate shall be thoroughly compacted by rolling and sprinkling when necessary. The rolling of the course shall be done with suitable rollers and as designated by the engineer. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding track by at least twelve (12) inches. The rolling shall continue until the base material is thoroughly set and bonded and there is no creeping ahead of the roller. Rolling shall continue until the base material has been compacted to not less than 95 percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, and uniformly compacted base. For final rolling, ten (10) ton three-wheel rollers shall be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer.

210-3.6 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown and, if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy are obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straight-edge applied to the surface parallel to the center line and at right angles.

210-3.7 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying, adding satisfactory base mixture, rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

210-3.8 PROTECTION. Work on the base course shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the aggregates contain frozen materials or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and

provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

210-3.9 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length and width by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping is completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The base shall be properly drained at all times. During this maintenance period any deficiencies in thickness, composition, smoothness, or density shall be corrected in a satisfactory manner.

Before preparations have started for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of binder. If during the curing period the surface of the base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

210-4.1 The quantity of caliche base course to be paid for shall be the number of cubic yards of base course material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position, based upon depth tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment. Base material shall not be included in any other excavation quantities.

BASIS OF PAYMENT

210-5.1 The quantity of caliche base course measured as provided above shall be paid for at the contract unit price per cubic yard for caliche base course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the ma-

terials; for mixing, blading, sprinkling, shaping, and compacting; for reconditioning the underlying course and shoulders; for reconstruction of irregular surface, or deficient thickness, and for maintenance; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit moves; for clearing, stripping, drainage, and clean-up of pits; for the handling and disposal of unsuitable materials encountered in pit operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-210-5.1 Caliche Base Course—per cubic yard.

ITEM P-211 LIME ROCK BASE COURSE

DESCRIPTION

211-1.1 This item shall consist of a base course composed of lime rock constructed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

MATERIALS

211-2.1 MATERIALS. The lime rock base course material shall consist of fossiliferous limestone of uniform quality, and shall not contain hard or flinty pieces which will prevent attainment of a smooth surface free from pits and pockets. The rock shall show no tendency to air slack or undergo chemical change when exposed to the weather. The material when watered and rolled shall be capable of being compacted into a dense and well-bonded base.

The oölitic type of lime rock shall meet the following requirements:

Carbonates of calcium and magnesium—not less than 80 percent.

Oxides of iron and aluminum—not more than 2 percent.

The combined amount of carbonates, oxides, and silica shall be at least 97 percent.

All other types of lime rock shall contain not less than ninety-seven (97) percent of carbonates of calcium and magnesium.

The chemical analysis of lime rock shall consist of determining the silica insoluble, iron oxide, and alumina by solution of the sample in hydrochloric (HCL) acid, evaporating, dehydrating, redissolving the residue and neutralizing with ammonium hydroxide, filtering, washing, and igniting the residue lime rock. The difference between this insoluble matter and one hundred (100) percent is reported as carbonates of calcium and magnesium.

The lime rock shall not contain more than three (3) percent of roots, leaf mold, organic, or foreign matter, and shall be obtained from pits from which all overburden has been removed previous to blasting and quarrying.

The gradation of the lime rock shall meet the following requirements:

Sieve designation	Percent by weight passing square mesh sieves
3½-inch.....	100
¾-inch.....	50-100

All fine material shall consist entirely of dust of fracture.

CONSTRUCTION METHODS

211-3.1 SOURCES OF SUPPLY. All work involved in cleaning and stripping pits, including handling unsuitable material encountered, shall be performed by the contractor at his own expense. The lime rock shall be obtained from sources that have been approved. The pits as utilized shall be operated in such a manner that a clean and uniform material is secured.

211-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

Powered rollers shall be of the three-wheeled type, weighing not less than ten (10) tons. Rollers shall have a rear-wheel compression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The roller shall be maintained in good condition and operated by an experienced rollerman.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course, upon approval of the engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Road machines shall weigh not less than three (3) tons and shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

211-3.3 PREPARING UNDERLYING COURSE. Before any rock base course material is placed, underlying course shall be prepared and conditioned as specified. The course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the lime rock shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

211-3.4 PLACING AND SPREADING. All base course material shall be placed on the prepared underlying course and compacted in layers to the thickness shown on the plans. The depositing and spreading of the material on the prepared course or on a completed layer shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. When more than one layer is required the construction procedure described herein shall apply similarly to each layer, excepting the scarifying and re-rolling of the surface. This shall apply to only the top layer.

The rock shall be transported to the points where it is to be used over rock previously placed, and dumped at the end of the preceding spread. It shall then be spread uniformly with shovels or forks or with spreaders especially constructed for this purpose. In no case shall rock be dumped directly on the underlying course. Transporting over the underlying course will not be permitted except as directed, in which case it must be protected by planking if rutting occurs. During the dumping and spreading operations the rock shall be thoroughly saturated with water as required. All segregated areas of fine or coarse rock shall be removed and replaced with well-graded rock to the satisfaction of the engineer. Lime rock shall not be spread when the subgrade is in unsuitable condition.

The lime rock base course shall be constructed in a layer of not less than four (4) inches nor more than six (6) inches of compacted thickness. The base course shall be constructed in lanes or strips parallel with the centerline of the paved area.

During the placing operation, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the lime rock.

211-3.5 ROLLING. Immediately following final spreading, the material shall be compacted to full width by rolling with a power roller or other approved compacting equipment. Rolling shall progress gradually from the sides to the center of the lane under construction, or from one side toward previously placed material, and shall continue until all the surface has been rolled and compacted. Rolling shall continue until the base material has been compacted to not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Large irregularities or depressions that develop under rolling shall be corrected by loosening the material at these places and adding or removing materials until the surface is smooth and uniform. Prior to and during compaction, water in the amounts as directed shall be applied as specified above. Sufficient rollers shall be furnished to properly compact the base course based on seventy (70) square yards per roller per hour of continuous operation. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, surface and until the

entire depth of base is compacted into a dense, unyielding mass. Re-rolling of previous day's spread shall be done as directed. When the shoulder back-fill material has been placed, the shoulder shall be thoroughly rolled and compacted.

Along curbs, headers, and all places inaccessible to the roller, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

211-3.6 FINISHING BASE COURSE. After the watering and rolling of the base course, the entire surface shall be scarified to a depth of at least three (3) inches and shaped to the exact crown and cross section with a road machine. The scarified material shall be rewatered and thoroughly rolled. Rolling shall continue until the base is bonded and compacted into a dense, unyielding mass, true to grade and cross section. The scarifying and rolling of the surface of the base shall follow the initial rolling of the lime rock by not more than four (4) days. When the lime rock base is constructed in two layers, the scarifying of the surface shall be to a depth of two (2) inches.

If at any time the underlying material becomes churned up and mixed with the base course material, the contractor shall, without additional compensation, dig out and remove the mixture, reshape and compact the underlying course, replace the materials removed with clean rock which shall be watered and rolled until satisfactorily compacted.

Where cracks, checks, or failures appear in the base either before or after priming and before the surface course is laid, the contractor shall remove such cracks, checks, or failure by rescarifying, reshaping, watering, rolling, and adding lime rock where necessary.

211-3.7 SURFACE TEST. The finished surface of the base course shall be tested with a sixteen (16) foot straightedge laid parallel to and at right angles to the centerline of the runway, and all irregularities greater than three-eighths ($\frac{3}{8}$) inch corrected by scarifying to a depth of not less than three (3) inches, removing or adding rock as may be required, after which the entire area shall be watered, rolled, and brought to a satisfactory state of compaction. In testing surface of the harder lime rocks, measurement of clearances from the straightedge shall not include small holes caused by individual pieces being pulled out by the grader.

211-3.8 THICKNESS. The thickness of the base course shall be determined by depth tests or elevations taken at intervals in such manner that one measurement shall represent 300 square yards, or as directed by the engineer.

The depth tests shall be made by test holes through the base at least three (3) inches in diameter. Where the base deficiency is more than one half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying and adding rock. The base shall be scarified, rock added, and tapered out for a distance of one hundred (100) feet in each direction from the edge of the deficient area for each inch of rock

added. The affected area shall then be watered, bladed, rolled, and brought to a satisfactory state of compaction and of required thickness and cross section. The thickness of the base in the affected area shall be remeasured by depth tests or elevations. The operations of scarifying, adding rock, and rerolling shall continue until the base thickness is within the one-half inch tolerance of base thickness. The final base thickness of the reconditioned area shall be used to determine the average job thickness.

The average job thickness shall be the average of the depth measurement as above outlined, and shall be within one-quarter ($\frac{1}{4}$) inch of the thickness as shown on the typical cross section. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as specified thickness plus one-half ($\frac{1}{2}$) inch in computing the average job thickness. The contractor shall replace, at his expense, the lime rock removed from test holes.

211-3.9 PROTECTION. Work on the base course shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the aggregate contains frozen materials, or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

211-3.10 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping is completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The base shall be properly drained at all times. During this maintenance period, any deficiencies in thickness, smoothness, or density shall be corrected in a satisfactory manner.

Before prime coat is applied, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of thickness of the base. If during the curing period the surface of base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

211-4.1 The yardage of lime rock base course to be paid for shall be the number of cubic yards of base material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position based upon depth tests taken as directed by the engineer at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half inch in excess of that shown on the plans shall be considered as the specified thickness plus one-half inch in computing the yardage for payment.

BASIS OF PAYMENT

211-5.1 The yardage of lime rock base course measured as provided above shall be paid for at the contract unit price bid per cubic yard for lime rock base course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the material; for blading, sprinkling, shaping, and compacting; for reconditioning the underlying course and shoulders; for reconstruction of irregular surface, or deficient thickness; for curing and for maintenance; for scarifying and rerolling; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit moves; for clearing, stripping, drainage, and clean-up of pits; for the handling and disposal of unsuitable materials encountered in pit operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

The cost of removing cracks and checks as provided above including the labor and material for repriming, and the additional lime rock where necessary on account of such crack elimination, will not be paid for separately but shall be included in the contract price per cubic yard for lime rock base course.

Payment will be made under:

Item P-211-5.1 Lime Rock Base Course—per cubic yard.

ITEM P-212 SHELL BASE COURSE

DESCRIPTION

212-1.1 This item shall consist of a base course composed of shell and binder constructed on a prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

MATERIALS

212-2.1 MATERIALS. The shell shall consist of durable particles of "dead" oyster or clam shell. The base material shall consist of oyster shell together with an approved binding or filler material so blended or processed as to produce a uniform mixture complying with the requirements of these specifications as to gradation, soil constants, and capability of being compacted into a dense and well-bonded base. Clam shell may be used in combination with oyster shell in the proportion up to and including fifty (50) percent.

The shell shall be reasonably clean and free from excess amount of clay or organic matter such as leaves, grass, roots, and other objectionable and foreign material.

The gradation of the blended or processed material shall meet the requirements of the gradation given in the table below, using A. A. S. H. O., Methods T-11 and T-27.

Sieve designation	Percent by weight passing square mesh sieves
3-inch.....	100
¾-inch.....	60- 90
¼-inch.....	15- 55
No. 200.....	0- 15

That portion of the material, including the blended filler, passing a No. 40 mesh sieve shall be known as soil binder and shall have a liquid limit of not more than 25 and a plasticity index of not more than 8 as determined by A. A. S. H. O. Methods T-89 and T-91, respectively.

If necessary, the contractor will be required to blend or combine materials so that the finally processed material meets all of the requirements of these specifications. The contractor will be required to

make such modifications in materials and methods as are necessary to secure a material which is capable of being compacted into a dense and well-bonded base without an excess of soil binder.

212-2.2 FILLER FOR BLENDING. If filler, in addition to that naturally present in the base course material, is necessary for satisfactory bonding of the material, for changing the soil constants of the material passing the No. 40 mesh sieve, or for correcting the gradation to the limitations of the specified gradation, it shall be uniformly blended with the base course material on the runway or at the plant. The material for such purpose shall be obtained from sources approved by the engineer and shall be of a gradation as necessary to accomplish the specified gradation in the finally processed material.

CONSTRUCTION METHODS

212-3.1 SOURCES OF SUPPLY. The contractor shall notify the engineer sufficiently in advance of the intended source of supply of shell. The shell shall be obtained from sources that have been approved. The material in the stock pile shall be handled in a manner that a uniform and satisfactory product will be secured.

212-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

Rollers shall be of the three-wheeled type power rollers weighing not less than ten (10) tons, and shall have a rear-wheel compression of not less than 330 pounds per linear inch of tire width. The roller shall be maintained in good condition and operated by an experienced rollerman.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course, upon approval of the engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates or screeds, or of other approved spreading devices, which will place the base material in a uniform layer with minimum of segregation.

Road machines shall weigh not less than three (3) tons and shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers.

Provision shall be made by the contractor for furnishing water at the plant or at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The processing plant shall be designed, constructed, operated, and of such capacity so as to thoroughly mix the shell, binder, and water in the proportions as directed to produce base material of the gradation and consistency required.

212-3.3 PREPARING UNDERLYING COURSE. Before any shell base course material is placed, the underlying course shall be prepared and conditioned as specified. The course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the shell shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

212-3.4 PLANT MIXING. When materials from several sources are to be blended and mixed or when required in the proposal, the shell base material shall be processed in a central mixing plant or in a travel mixing plant. The shell together with any blended material shall be thoroughly mixed with the required amount of water. After the mixing is complete the material shall be transported to or spread on the underlying course without undue loss of the moisture content.

212-3.5 PLACING AND SPREADING. The base course material that is correctly proportioned or has been processed in a central plant shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The materials shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The material shall be spread by the use of spreader boxes or other approved devices that shall distribute the material in a uniform layer. Dumping from vehicles in piles so as to require rehandling will not be permitted. Hauling over the uncompacted base course shall not be allowed.

212-3.6 TRAVEL PLANT MIX. When the use of a travel plant is approved sufficient quantities and proportions of all material necessary to provide a base mixture conforming to the specified gradation, quality, and thickness shall be placed. If a window type of travel plant is employed for mixing, the aggregate shall be placed in windrows parallel to the pavement centerline. If a traveling plant is used which

is of the type that mixes previously spread aggregates in-place, the material shall be spread to such thickness as may be readily handled by the machine and to develop the thickness for each layer. The base material shall be mixed at a satisfactory moisture content to obtain maximum density.

After the mixing has been completed, the base material shall be spread to the required depth and width by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading, care shall be taken to prevent cutting into the underlying layer. The material shall be bladed, disced, and dragged if necessary until a smooth, uniform surface is obtained true to line, grade, and cross section and in condition for compacting.

212-3.7 MIXED IN-PLACE. When the base materials are to be proportioned and mixed or blended in-place on the runway the different layers shall be spread and placed in the following manner, the relative proportions of the components of the mixture being as designated by the engineer.

The base aggregate shall be deposited and spread evenly on the subgrade to a uniform thickness and width. Then the binder or filler shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the engineer may direct to obtain the required base mixture.

When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary-tillers, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniform throughout. Areas of segregated material shall be corrected by the addition of binder or filler material and thoroughly remixed. Water in the amount and as directed by the engineer shall be uniformly applied, prior to and during the mixing operations if necessary, to maintain the material at the proper moisture content. When the mixing and blending has been completed, the material shall be spread in a uniform layer which when compacted will meet the requirements of thickness and typical cross section.

212-3.8 GENERAL METHODS FOR PLACING. The base course shall be constructed in a layer of not less than four (4) inches nor more than six (6) inches of compacted thickness. Each layer shall be tested by depth blocks. The aggregate as spread shall be of uniform gradation with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within this limit. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

The engineer will make tests to determine the maximum density and the proper moisture content of the base material, and this information will be available to the contractor. The base material shall be

brought to a satisfactory moisture content before rolling is started either by sprinkling and mixing or by aeration.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

212-3.9 FINISHING AND COMPACTING. After spreading or mixing, the aggregate shall be thoroughly compacted by rolling and sprinkling when necessary. The initial rolling of the course shall be done with suitable three-wheeled ten-ton rollers or other approved equipment. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. The rolling shall continue until the shell is thoroughly set, the interstices of the metal reduced to a minimum, and creeping ahead of the roller no longer visible. Rolling shall continue until the base material has been compacted to not less than ninety-five (95) percent density as determined by the CAA compaction control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, and uniformly compacted base. For final rolling, ten-ton three-wheel rollers shall be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened, then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer.

212-3.10 SURFACE TEST. After the course is completely compacted the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straightedge applied to the surface parallel to the centerline and at right angles.

212-3.11 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. Where the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by taking up the base material, removing and replacing with satisfactory materials properly laid, rolled, bonded, and finished in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

212-3.12 PROTECTION. Work on the base course shall not be prosecuted during freezing temperatures nor when the subgrade is wet. When the aggregates contain frozen materials or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course, to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

212-3.13 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping is completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The base shall be properly drained at all times. During this maintenance period, any deficiencies in thickness, composition, smoothness, or density shall be corrected in a satisfactory manner.

Before preparations have started for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of binder. If, during the curing period, the surface of the base dries too fast it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

212-4.1 The quantity of shell base course to be paid for shall be the number of cubic yards of base course material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position based upon depth

tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half inch in excess of that shown on the plans shall be considered as specified thickness plus one-half ($\frac{1}{2}$) inch in computing the yardage for payment. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

212-5.1 The quantity of shell base course material measured as provided above shall be paid for at the contract unit price per cubic yard for shell base course, which price and payment shall constitute full compensation for furnishing, hauling, and placing the materials; for blading, sprinkling, and rolling; for reconditioning the underlying course and shoulders; for any required construction, repair, and obliteration of access roads; for all pit moves; for clearing, stripping, and cleanup of stock piles; for the handling and disposal of unsuitable materials encountered in stock-pile operations; for reconstruction of irregular surface or deficient thickness and maintenance; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-212-5.1 Shell Base Course—per cubic yard.

ITEM P-213 SAND-CLAY BASE COURSE

DESCRIPTION

213-1.1 This item shall consist of a base course composed of approved selected material, constructed on a prepared underlying course, in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with lines and grades established by the engineer.

MATERIALS

213-2.1 SAND-CLAY. The materials shall consist of a mixture of clay and mineral aggregate, constituting topsoil, sand-clay, sand-clay gravel, disintegrated granite, marl, or other approved selected aggregate, and shall contain sufficient binder material so blended or processed as to produce a uniform mixture complying with the requirements of these specifications as to gradation, soil constants, and capability of being compacted into a dense and well-bonded base without an excess of soil binder.

The materials shall be uniform and free from excess amounts of clay or organic matter such as leaves, grass, roots, and other objectionable or foreign substances. The coarse aggregate (particles coarser than a No. 4 mesh sieve) shall consist of hard, durable pieces or fragments of stone or gravel.

The gradation of the blended or processed material shall meet the requirements of the gradation given in the tables below, using A. A. S. H. O. Methods T-11 and T-27.

Sieve designation	Percent by weight passing square openings	
	Coarse aggregate type	Fine aggregate type
1½-inch.....	100	100
1-inch.....	85-100	85-100
¾-inch.....	50- 80	70-100
No. 10.....	30- 60	60-100

The soil mortar (material passing the No. 10 mesh sieve) shall conform to the following gradation requirements:

Sieve designation	Percent by weight passing square openings
No. 10.....	100
No. 40.....	35- 70
No. 200.....	8- 25

The fraction passing the No. 40 mesh sieve shall be referred to as binder. The fraction passing the No. 200 mesh sieve shall be less than one-half the fraction passing the No. 40 mesh sieve. The material passing the No. 40 mesh sieve shall have a plasticity index not to exceed 4 and have a liquid limit of not more than 25, when tested in accordance with A. A. S. H. O. Methods T-89, T-90, and T-91 for the fine aggregate type; the plasticity index shall not exceed 6 and the liquid limit shall not exceed 25 for coarse aggregate type.

If necessary, the contractor will be required to blend or combine materials so that the finally processed material meets all of the requirements of these specifications and the intended purpose of this item of base. The contractor will be required to make such modifications in materials and methods as are necessary to secure a material which is capable of being compacted into a dense and well-bonded base without an excess of soil binder.

213-2.2 FILLER FOR BLENDING. If filler, in addition to that naturally present in the base course material, is necessary for satisfactory bonding of the material, for changing the soil constants of the material passing the No. 40 mesh sieve, or for correcting the gradation to the limitations of the specified gradation, it shall be uniformly blended with the base course material. The material for such purpose shall be obtained from sources approved by the engineer and shall be of a gradation as necessary to accomplish the specified gradation in the finally processed material.

CONSTRUCTION METHODS

213-3.1 OPERATION IN PITS. All work involved in clearing and stripping pits, including handling unsuitable material encountered shall be performed by the contractor at his own expense. The base material shall be obtained from pits or sources that have been approved. The material in the pits shall be excavated and handled in a manner that assures a uniform and satisfactory product.

213-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than ten (10) tons. The roller shall have a rear-wheel com-

pression of not less than 330 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The tamping roller shall consist of metal rollers, drums, or shells surmounted by metal studs with tamping feet projecting not less than seven (7) inches from the surface of the roller, drum, or shell. The area of each tamping foot shall be from four (4) to twelve (12) square inches. Each roller shall consist of two sections and the length of each section shall be not less than four (4) feet. When the roller is empty, it shall produce at least 120 pounds per square inch of area of tamping feet in contact with the ground. The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

Road machines shall weigh not less than three (3) tons and shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The processing equipment shall be designed, constructed, operated, and of such capacity so as to thoroughly mix all materials and water in the proportions as directed to produce a base course of the gradation and consistency required.

213-3.3 PREPARING UNDERLYING COURSE. Before any base course material is placed, the underlying course shall be prepared and conditioned as specified. The course shall be checked and accepted by the engineer before placing and spreading operations are started.

Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled to the required compaction before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section, or on the high side of the pavement with a one-way slope.

213-3.4 PLANT MIXING. When materials from several sources are to be blended and mixed, or when required in the proposal, the base material shall be processed in a central mixing plant or in a travel mixing plant. The sand-clay, together with any blended material, shall be thoroughly mixed with the required amount of water. After the mixing is complete the base material shall be transported to

and spread on the underlying course without undue loss of the moisture content.

213-3.5 PLACING AND SPREADING. The base course material that is correctly proportioned or has been processed in a plant shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The material shall be spread by the use of spreader boxes, approved devices, or moving vehicles equipped to distribute the material in a uniform layer.

When approved, the material may be dumped in piles, but shall be spread immediately. Hauling over the uncompacted base course shall not be allowed.

213-3.6 TRAVEL PLANT MIX. When the use of a travel plant is approved, sufficient quantities and proportions of all material necessary to provide a base mixture conforming to the specified gradation, quality, and thickness shall be placed. If a windrow-type of travel plant is employed for mixing, the sand-clay shall be placed in windrows parallel to the pavement centerline. If a traveling plant is used which is of the type that mixes previously spread material in-place, the sand-clay shall be spread to such thickness as may be readily handled by the machine and to develop the thickness for each layer. The base material shall be mixed at a satisfactory moisture content to obtain maximum density.

After the mixing has been completed, the base material shall be spread to the required depth and width by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading, care shall be taken to prevent cutting into the underlying layer. The material shall be bladed, disced, and dragged if necessary until a smooth, uniform surface is obtained true to line, grade, and cross section, and in condition for compacting.

213-3.7 MIXED IN-PLACE. When the base materials are to be proportioned and mixed or blended in-place, the different layers shall be spread and placed in the following manner, the relative proportions of the components of the mixture being as designated by the engineer.

The base aggregate shall be deposited and spread evenly on the subgrade to a uniform thickness and width. Then the binder or filler shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the engineer may direct to obtain the required base mixture.

When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary-tillers, supplemented by other suitable equipment

if necessary. The mixing shall continue until the mixture is uniform throughout. Areas of segregated material shall be corrected by the addition of binder or filler material and by thorough remixing. Water in the amount and as directed by the engineer shall be uniformly applied prior to and during the mixing operations if necessary, to maintain the material at the proper moisture content. When the mixing and blending has been completed, the material shall be spread in a uniform layer which, when compacted, will meet the requirements of thickness and typical cross section.

213-3.8 GENERAL METHODS FOR PLACING. The base course shall be constructed in a layer of not less than four (4) inches nor more than six (6) inches of compacted thickness. Each layer shall be tested for depth. The material as spread shall be of uniform gradation, with no pockets of fine or coarse materials. The base, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling. Any necessary sprinkling shall be kept within this limit. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

The engineer will make tests to determine the maximum density and the proper moisture content of the base material, and this information will be available to the contractor. The base material shall be brought to a satisfactory moisture content before rolling is started, either by sprinkling and mixing or by aeration.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

213-3.9 FINISHING AND COMPACTING. After spreading or mixing, the base material shall be thoroughly compacted by rolling and sprinkling when necessary. The initial rolling of the course shall be done with tamping rollers. A single roller shall perform the rolling for not more than twenty-five (25) cubic yards per hour, and additional rollers shall be provided when the spreading is greater than this rate.

Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material, by lapping uniformly each preceding track by at least twelve (12) inches. The rolling shall continue until the base material is thoroughly set and bonded and there is no creeping ahead of the roller. Rolling shall continue until the base material has been compacted to not less than ninety-five (95) percent density, as determined by the CAA compaction-control tests T-611 for the class of airport involved. Blading and rolling shall be done alternately as required or directed to obtain a smooth, even, and uniformly compacted base. For final rolling the ten-ton three-wheel roller shall be used.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course. When the rolling develops irregularities that exceed three-

eighths ($\frac{3}{8}$) of an inch when tested with a sixteen (16) foot straight-edge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

The sprinkling during rolling, if necessary, shall be in the amount and by equipment approved by the engineer.

213-3.10 SURFACE TEST. After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be scarified, reshaped, recompactd, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straight-edge applied to the surface parallel to the centerline and at right angles.

213-3.11 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying, adding satisfactory base mixture, rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

213-3.12 PROTECTION. Work on base course shall not be prosecuted during freezing temperature nor when the subgrade is wet. When the base material contains frozen material or the underlying course is frozen, the construction shall be stopped.

In general, hauling equipment may be routed over completed portions of the base course, provided no excessive damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his opinion, such hauling is causing excessive damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the contractor at his own expense.

213-3.13 MAINTENANCE. Following the final shaping of the material, the base shall be maintained throughout its entire length by the use of a standard road machine or motor grader and rollers until such time as, in the judgment of the engineer, the base meets the required density, is properly bonded, and is suitable for priming. After the mixing and shaping are completed, the base shall be confined to the specified width by banking enough shoulder material against the edges to prevent it from spreading under traffic. The

base shall be properly drained at all times. During this maintenance period, any deficiencies in thickness, composition, smoothness, or density shall be corrected in a satisfactory manner.

Before preparations have started for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than eighty (80) percent of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with a consequent loss of binder. If during the curing period the surface of the base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat shall be applied as directed.

METHOD OF MEASUREMENT

213-4.1 The yardage of sand-clay base course to be paid for shall be the number of cubic yards of base course material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position based upon depth tests or cores taken as directed by the engineer, or at the rate of one depth test for each 300 square yards of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot. On individual depth measurements, thicknesses more than one-half ($\frac{1}{2}$) inch in excess of that shown on the plans shall be considered as the specified thickness plus one-half inch in computing the yardage for payment. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

213-5.1 The yardage of sand-clay base course measured as provided above shall be paid for at the contract unit price bid per cubic yard for sand-clay base course, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the materials; for mixing, blading, sprinkling, shaping, and compacting; for reconditioning the underlying course and shoulders; for reconstruction of irregular surface, or deficient thickness, and for maintenance; for refilling test holes; for any required construction, repair, and obliteration of access roads; for all pit moves; for clearing, stripping, drainage, and clean-up of pits; for handling and disposal of unsuitable materials encountered in pit operations; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Payment will be made under:

Item P-213-5.1 Sand-Clay Base Course—per cubic yard.

ITEM P-214 PENETRATION MACADAM BASE COURSE (Emulsified Asphalt Type)

DESCRIPTION

214-1.1 This item shall consist of a base course composed of macadam, asphalt-bonded, constructed on a prepared underlying layer in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer.

214-1.2 QUANTITIES OF MATERIALS PER SQUARE YARD. The finished thickness of the penetration macadam base shall be as specified or as shown on the plans. The quantities of aggregate and emulsified asphalt shall be as given in Table 1, opposite the particular thickness shown on the plans for the base. At the beginning of construction and during its progress, the individual weights of the various aggregates shall be varied and adjusted as directed by the engineer in accordance with field requirements.

TABLE 1.—*Quantities of Materials per Square Yard*

Compacted thickness indicated on plans	Coarse aggregate		Choke aggregate		First application emulsion	Keystone		Second application emulsion	Total aggregate	Total emulsion
	Grad.	Lbs.	Grad.	Lbs.	Gals.	Grad.	Lbs.	Gals.	Lbs.	Gals.
2" course.....	B	140	D	20	0.6-0.8	C	25	0.9-1.0	185	1.5-1.8
3" course.....	A	225	D	28	0.9-1.1	C	35	1.2-1.3	288	2.1-2.4

The weights given in Table 1 are approximate and are for aggregates having a bulk specific gravity of 2.65, as determined by the A. A. S. H. O. Method T-85. Proportionate corrections shall be made when the aggregates furnished have bulk specific gravities above 2.75 or below 2.55. In such cases the corrected amount shall be the product of the number of pounds shown in Table 1 multiplied by the ratio of the bulk specific gravity of the aggregate to 2.65.

In Table 1 the amounts of emulsion given are for stone aggregates. If the total aggregate is composed of slag, the gallons of emulsion shall be increased from fifteen (15) to twenty (20) percent.

MATERIALS

214-2.1 AGGREGATE. The coarse aggregate, key stone, and screenings shall be either crushed stone or crushed slag.

The crushed stone shall consist of hard, durable particles or fragments of stone, free from an excess of flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter, and shall have a percent of wear of not more than 45 at 500 revolutions, as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed slag shall be air-cooled blast furnace slag, and shall consist of angular fragments, reasonably uniform in density and quality, and reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than sixty-five (65) pounds per cubic foot, and shall have a percent of wear of not more than 45 at 500 revolutions, as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The crushed aggregate shall not show evidence of disintegration nor show a total loss greater than twelve (12) percent when subjected to five (5) cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

Crushed stone and crushed slag for coarse aggregate, key stone, and screenings shall meet the requirements for gradation given in Table 2, using A. A. S. H. O. Method T-27.

TABLE 2.—Requirements for Gradation of Aggregate

Sieve designation	Percentage by weight passing square mesh sieves			
	Gradation A	Gradation B	Gradation C	Gradation D
3-inch.....	100			
2½-inch.....	90-100	100		
2-inch.....	35- 70	90-100		
1½-inch.....	0- 15	35- 70		
1-inch.....		0- 15		
¾-inch.....	0- 5		100	
½-inch.....		0- 5	90-100	100
⅜-inch.....			40- 70	85-100
No. 4.....			0- 15	10- 30
No. 8.....			0- 5	0- 10

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample by immersing at least two (2) pounds of the aggregate in the emulsified asphalt for a period of approximately ten (10) minutes. After the sample has been prepared, it shall be spread out in a loose thin layer and placed in a constant temperature oven-controlled to 140° F. for a period of twenty-four (24) hours before testing. A suitable size sample (approximately one-half contents of container)

shall be tested by placing it in a glass jar fitted with a tight screw cap. The sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any trace of soap or saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample shall be examined for stripping. If any stripping or sloughing off of the bituminous coating occurs, it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state, or the aggregate shall be rejected.

214-2.2 EMULSIFIED ASPHALT. The emulsified asphalt shall be a quick-setting emulsion that is homogeneous and that will show no separation after thorough mixing. When tested as herein specified, the emulsion shall conform to the following requirements:

TABLE 3.—*Requirements for Emulsified Asphalt*

Test requirements	A. A. S. H. O. test method	Limits
Viscosity, Saybolt Furol, at 77° F., sec.....	T-59	30-70
Residue at 325° F., percent.....	T-59	55-65
Demulsibility: 35 ml. N/50, CaCl ₂ , not less than, percent.....	T-59	60
Settlement, 10 days, not more than, percent.....	T-59	3
Sieve test, not more than, percent.....	T-59	0.05
Sampling Material.....	T-40	-----

The residue from distillation shall have the following characteristics:

Specific Gravity 77° F./77° F., not less than.....	T-43	1.00
Penetration at 77° F., 100 g., 5 sec.....	T-49	100-200
Solubility in Carbon Disulphide, not less than, percent.....	T-44	97
Ash, not more than, percent.....	T-59	2
Ductility at 77° F., not less than, cm.....	T-51	60

The asphalt cement shall not be cracked.

Ductility.—When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot, and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility.

The Oliensis Spot Test may be used to identify products manufactured by the cracking process which show a positive spot when present in sufficient proportions. The test should be modified to differentiate between cracked asphalts and those asphalts from some crude sources that have never been cracked but show a positive spot. The asphalt shall be tested prior to emulsification.

CONSTRUCTION METHODS

214-3.1 WEATHER LIMITATIONS. The emulsified asphalt penetration base shall be constructed and operations carried on only when the surface of the underlying course and the base is dry, when the atmospheric temperature is above 45° F. and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

214-3.2 EQUIPMENT. (a) *General.* All methods employed in performing the work and all equipment, tools, and other machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started; and whenever found unsatisfactory, shall be changed and improved as required. All equipment, tools, and machinery used must be maintained in a satisfactory working condition.

(b) *Drag Brooms.* The drags shall be of rectangular shape and not less than seven (7) feet by twelve (12) feet. They shall be so designed that, when pulled at a uniform rate of speed, they will distribute stone chips and keystone over the surface without leaving waves or ridges of material, and without loosening or removing the coarse aggregate. Fibre brooms are preferred to other types.

(c) *Pressure Distributor.* The distributor shall have pneumatic tires of such width and number that the load produced on the runway course shall not exceed 650 pounds per inch of tire width, and shall be so designed, equipped, maintained, and operated that bituminous material may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, and a thermometer for reading temperatures of tank contents.

(d) *Rolling Equipment.* The steel-wheel rollers shall be of the self-propelled type with the tandem rollers weighing at least eight (8) tons and the three-wheel rollers weighing at least ten (10) tons. The wheels of the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surfaces.

(e) *Spreading Equipment.* The spreading equipment shall consist of spreader boxes and/or other approved mechanical spreading devices for placing the required amounts of the crushed aggregate, the choke aggregate, and the keystone. The materials shall be spread and placed in a manner to avoid or minimize the need for hand manipulation. Dumping from vehicles in piles or windrows on the paved area so as to require rehandling will not be permitted.

214-3.3 PREPARING UNDERLYING COURSE. Before any base course material is placed, the underlying layer shall be prepared and conditioned as specified. The underlying course shall be

checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear because of improper drainage conditions, hauling, or from any other cause shall be corrected and rolled until firm before the base course is placed.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

214.-3.4 PLACING AND SPREADING COARSE AGGREGATE. The coarse aggregate as designated in Table I shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the aggregate shall commence where designated and shall progress continuously without breaks. The aggregate shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the required thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The base aggregate shall be spread by the use of approved spreading equipment that shall spread the aggregate in the required amount so as to avoid or minimize the need for hand manipulation. The spreaders shall be equipped with a strike-off gate or similar means that can be adjusted or controlled to secure the required thickness of the base. Hauling over the uncompacted base course shall not be permitted.

The surface of the aggregate shall then be carefully trued up and all high or low spots remedied by removing or adding aggregates, as may be required. It shall be lightly rolled, after which the surface shall again be trued up. This operation shall be repeated until a uniform surface is secured which, when tested with a sixteen (16) foot straightedge, shall be found to be free from high or low spots.

The base course shall be constructed in a layer of not less than two (2) inches nor more than three (3) inches of compacted thickness. The coarse aggregate as spread shall be of uniform grading, with no pockets of fine materials. Coarse aggregate, unless otherwise permitted by the engineer, shall not be spread more than 2,000 square yards in advance of the rolling and choking. No material shall be placed in snow or on a soft, muddy, or frozen subbase.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

During the placing and spreading or any other operation, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base aggregate.

214-3.5 ROLLING. Immediately following the spreading and truing of the surface of the coarse aggregate, it shall be compacted to the full width by rolling with a three-wheel power roller weighing at least ten (10) tons. Rolling shall progress gradually from the sides to the center of the lane under construction or from one side toward previously placed material by lapping uniformly each preceding rear-wheel track by one-half ($\frac{1}{2}$) the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. The rolling shall continue until the stone is thoroughly interlocked, the interstices of the metal reduced to a minimum, and creeping of the stone ahead of the roller no longer visible.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes a wavelike motion in the base course, underlying course, or subgrade. When the rolling develops irregularities that exceed three-eighths ($\frac{3}{8}$) inch when tested with a sixteen (16) foot straightedge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course, and again rolled as required above.

Along places inaccessible to rollers, the base course material shall be tamped thoroughly with mechanical or hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

214-3.6 APPLICATION OF CHIPS FOR FILLING VOIDS. The voids in the coarse aggregate placed as above described shall then be filled to within one-half ($\frac{1}{2}$) inch of the surface with chips designated in Table 1 as "choke aggregate." The chips shall be evenly spread with approved devices, and shall be thoroughly rolled and lightly broomed until worked down. Care shall be taken to prevent chips from bunching or caking on the surface. If necessary to insure complete filling of the voids, spreading of the chips shall be made in more than one application.

214-3.7 FIRST APPLICATION OF EMULSIFIED ASPHALT AND KEYSTONE. Upon the surface prepared as above described, emulsified asphalt shall be uniformly applied with pressure distributors at the rate per square yard specified in Table 1. Immediately following this application of emulsified asphalt, keystone of gradation indicated in Table 1 shall be uniformly spread in quantity sufficient to completely fill the remaining voids. This shall be broom-dragged and thoroughly rolled. Additional keystone, if required, shall be spread, and rolling and brooming shall continue until the voids in the coarse aggregate are completely filled and the keystone is thoroughly locked into the surface. No excess loose stone will be permitted.

214-3.8 SECOND APPLICATION OF EMULSIFIED ASPHALT. The second application of emulsified asphalt shall then be made at the rate shown in Table 1. It is intended that this application shall act as a tack coat as well as penetrate and bond the base aggregate. The timing of this application shall be as directed

182 214. PENETRATION MACADAM BASE COURSE

by the engineer. The second application shall be made early enough following the previous construction to properly protect the base course, and sufficiently in advance of the surfacing to allow the emulsified asphalt to set and dry. After this application, the surface shall be rolled.

214-3.9 ROLLING TIME AND ROLLERS. A sufficient number of rollers shall be furnished on the work to provide one roller for each twenty-five (25) tons of aggregate laid per hour. The rolling shall be so distributed following the various applications of aggregate as required by the engineer to get the maximum density in the finished base. Tandem rollers may be used at the option of the contractor on all operations except in compaction and consolidation of the coarse aggregate.

214-3.10 SURFACE TEST. After the final application of the emulsified asphalt, the surface shall be tested for smoothness and accuracy of grade and crown, and if any portions are found to lack the required smoothness or to fail in accuracy of grade or crown, such portions shall be reshaped, retreated, recompacted, and otherwise manipulated as the engineer may direct until the required smoothness and accuracy is obtained. The finished surface shall be such that it will not vary more than three-eighths ($\frac{3}{8}$) of an inch from the sixteen (16) foot straightedge applied to the surface parallel to the centerline and at right angles.

214-3.11 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent not more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch the contractor shall correct such areas by adding satisfactory base aggregate, rolling, choking, penetrating with emulsified asphalt, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

214-3.12 MAINTENANCE. Following the completion of the construction of the base course, the contractor shall maintain and protect same. All maintenance work that is necessary to keep the surface in a satisfactory condition shall be performed as directed. The surface shall be kept clean and free from foreign material. If the surface becomes dirty it shall be cleaned and an additional tack coat applied at the expense of the contractor.

214-3.13 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the emulsified asphalt that the contractor proposes to use, together with a statement as to its source and character, must be submitted and approval obtained before use of such material begins.

The contractor shall furnish vendors' certified test report for each carload or equivalent of emulsified asphalt shipped to the project. The report shall be delivered to the engineer before permission is granted for the use of the material. The furnishing of the vendors' certified test report for the emulsified asphalt shall not be interpreted as a basis

for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

214-3.14 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills where materials are received in any other manner, of the emulsified asphalt and aggregates actually used in the construction covered by the contract. The contractor shall not remove emulsified asphalt from the tank car or storage tank until the initial outage and temperature measurements have been taken by the engineer, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

214-4.1 The yardage of penetration macadam base course to be paid for shall be the number of square yards of material placed, penetrated, and accepted in the completed base course.

The gallons of emulsified asphalt used in the accepted work shall not be measured and paid for separately but the cost of same shall be included in the price bid in the schedule per square yard for the penetration macadam base course, and shall be considered incidental to the price for the base.

BASIS OF PAYMENT

214-5.1 The yardage of penetration macadam base course determined as described in 4.1 above shall be paid for at the contract unit price per square yard in the bid schedule for penetration macadam base course, which price and payment shall constitute full compensation for furnishing, delivering, hauling, and placing all materials; for spreading, brooming, choking, penetrating, and rolling; for covering excess bituminous material; for reconditioning the underlying course and shoulders; for removal of excess aggregate; for reconstruction of damaged or deficient base; for maintenance of surface; for clearing, cleaning, and leveling of stock pile; for refilling test holes; and for all labor, equipment, tools, and incidentals necessary to complete the base.

Payment will be made under:

Item P-214-5.1 Penetration Macadam Base Course—per square yard.

ITEM P-215 EMULSIFIED ASPHALT AGGREGATE BASE COURSE (Central Plant Mix)

DESCRIPTION

215-1.1 This item shall consist of a base course composed of mineral aggregate and emulsified asphalt, mixed in a central mixing plant, and placed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with lines and grades established by the engineer.

215-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of emulsified asphalt, by weight, to be added to the aggregate shall be fixed by the engineer on the basis of preliminary laboratory tests and field sieve analysis on the aggregate furnished and shall be within the range as shown in the table.

215-1.3 JOB MIX FORMULA. No work shall be started on the project, nor any mixture accepted therefor, until the contractor has submitted samples of the materials intended for use, and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate and for emulsified asphalt. The mixture furnished shall conform to the approved job mix formula within the tolerances specified herein:

JOB MIX TOLERANCES

	<i>Plus or Minus</i>
Aggregate passing sieves No. 4 and larger-----	7 percent.
Aggregate passing No. 40 sieve-----	5 percent.
Aggregate passing No. 200 sieve-----	2 percent.
Emulsified Asphalt-----	0.5 percent.

MATERIALS

215-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, screenings, gravel, sand-gravel, or other natural granular approved materials.

The aggregate shall be tough, durable, and sound. The coarse aggregate when tested in accordance with the Los Angeles Rattler Test,

after five hundred (500) revolutions, shall have a percent of wear of not more than fifty (50) according to the A. A. S. H. O. Method T-96.

The composite material shall meet the requirements for one of the gradations given in Table 2, using A. A. S. H. O. Methods T-11 and T-27.

The aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subject to five (5) cycles of the sodium sulphate soundness test using A. A. S. H. O. Method T-104.

That portion of the fine aggregate, including any blended filler, passing a No. 40 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91, and a liquid limit of not more than 25, as determined by A. A. S. H. O. Method T-89.

The composite aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The bituminized aggregate shall have a swell of not more than one and one-half ($1\frac{1}{2}$) percent as determined by A. A. S. H. O. Method T-101.

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample of the base mixture in conformity with these specifications and using the maximum amount of moisture allowed. After the mixture has been made, it shall be spread out in a loose thin layer and placed in a constant temperature oven, controlled to 140° F., for a period of twenty-four (24) hours before testing. A suitable size sample (approximately one-half contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap; the sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing off of the bituminous coating occurs it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydropilic to a hydrophobic state, or the aggregate shall be rejected.

215-2.2 BITUMINOUS MATERIAL. The emulsified asphalt shall be homogeneous and of such character that it will mix with distilled water in all proportions and shall meet the requirements of Table 1.

TABLE 1.—*Requirements for Emulsified Asphalt*

Test requirements	A. A. S. H. O. test method	Limits
Viscosity, Saybolt Furol, at 77° F., sec.-----	T-59	20-120
Residue at 325° F., percent.-----	T-59	55-65
Oil distillate, by volume, not less than, percent.-----		1
not more than, percent.-----		3
Demulsibility: 50 ml. of 0.1 N CaCl ₂ , not less than, percent.-----	T-59	30
Sieve Test, not more than, percent.-----	T-59	0.05
Settlement 5 days, not more than, percent.-----	T-59	5
Stone Coating Test.-----	T-59	Shall pass
Sampling Material.-----	T-40	

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F., not less than.-----	T-43	0.96
Penetration at 77° F., 100 g., 5 sec.-----	T-49	150-225
Soluble in Carbon Tetrachloride, not less than, percent.-----	T-45	97
Ductility at 77° F., not less than, cms.-----	T-51	60

The material shall not be cracked.

The settlement test shall be as shown in the table and will be waived when the emulsified asphalt is manufactured and used in less than five (5) days' time. The engineer may require the settlement test be run from the time when the emulsified asphalt sample is received until the material is approved for use.

The base asphalt for the emulsified asphalt shall have a range of penetration at 77° F., 100 g., 5 sec. of 150-225. The mixture of emulsified asphalt and aggregate after curing shall develop no indication of re-emulsifying due to its coming in contact with moisture or water. The emulsified asphalt shall be of such stability that it will remain constant and uniform while being combined and mixed with the aggregate, and shall show satisfactory mixing properties when combined with the aggregates without balling up or becoming hard or tacky.

Coating test shall not show appreciable separation when emulsified asphalt is mixed with the washed, dry, clean stone for three (3) minutes. The emulsified asphalt shall coat the stone thoroughly.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility.

The Oliensis Spot Test may be used to identify products manufactured by the cracking process, which show a positive spot when present in sufficient proportions. The test should be modified to differentiate between cracked asphalts and those asphalts from some crude sources that have never been cracked but show a positive spot. The asphalt shall be tested prior to emulsification.

215-2.3 FILLER. If filler in addition to that naturally present in the aggregate is necessary, it shall consist of stone dust, loess, Portland cement, or other approved mineral matter. The filler material shall meet the requirements of A. A. S. H. O. Specification M-17.

215-2.4 HYDRATED LIME. If and when used, the hydrated lime shall meet the requirements of the A. S. T. M. Designation C-6.

COMPOSITION OF MIXTURE

215-3.1 GRADATION OF AGGREGATE. The mineral aggregate for the base course shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to one of the following gradations:

TABLE 2.—*Requirements for Gradation of Aggregate*

Sieve size	Percentage by weight passing (square openings)		
	A 2" maximum	B 1½" maximum	C 1" maximum
2-inch.....	100		
1½-inch.....		100	
1-inch.....	55- 85	70- 95	100
¾-inch.....	50- 80	55- 85	70-100
No. 4.....	32- 62	32- 62	35- 65
No. 40.....	10- 35	10- 35	10- 30
No. 200.....	0- 5	0- 5	0- 5

The gradations in this table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The gradations of the composite mix shall be within the limits designated in the table, shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The selection of any of the gradations shown in the table shall be such that the maximum size aggregate used in any course shall not be more than one-half ($\frac{1}{2}$) the thickness of the layer of the course being constructed.

The composition limits tabulated shall govern, but a closer control appropriate to the job materials will be required for the specific project in accordance with a job mix formula.

The total amount of material passing the No. 200 mesh sieve shall be determined by washing the material through the sieve with water and not less than one-half ($\frac{1}{2}$) of the material passing the No. 200 mesh sieve by washing shall pass the No. 200 mesh sieve by dry sieving without washing.

215-3.2 PROPORTION OF EMULSIFIED ASPHALT.

The proportion of emulsified asphalt by weight and the percent of bitumen shall be one of the following:

Gradation of aggregate	Emulsified asphalt, percentage by weight	Percent bitumen by weight
A.....	4 -6	2.4-3.6
B.....	4.5-6.5	2.7-3.9
C.....	5 -7	3.0-4.2

CONSTRUCTION METHODS

215-4.1 WEATHER LIMITATIONS. Base course shall be constructed and operations shall be carried on only when the surface is dry, when the atmospheric temperature is above 50° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

215-4.2 EQUIPMENT AND ORGANIZATION. (a) *General.* All methods employed in performing the work and all equipment, tools, plant, and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The paving plant used by the contractor in the preparation of the base mixture shall comply with the following requirements:

The plant shall have a storage bin, protected from the weather, of sufficient capacity to furnish the necessary amount of aggregate when operating at the maximum rated capacity of the plant.

The plant may have either batch weighing or volumetric proportioning of mineral aggregates and emulsified asphalt. This equipment shall be constructed with devices that will permit easy readjustment of any working part such that it will function properly and accurately. The aggregate weighing or measuring device shall be so constructed and operated that the correct amount of aggregate is introduced into the mixer with an accuracy that will meet the job tolerances specified. The plant shall have a capacity of at least one hundred (100) tons per hour.

The asphalt weighing or measuring device shall be so constructed and operated that the correct amount of emulsified asphalt is introduced into the mixer with an accuracy that will meet the job tolerance specified. If weight control is used, the dial scales or other weighing device shall be of an approved type.

The mixer shall be of sufficient size to maintain uniform and thorough mixing and be of the following type: The mixer shall be a pul-

verizing-type mixer equipped with an approved volumetric proportioning system for aggregate and asphalt. The pulverizers shall be mounted laterally to the direction of flow of the aggregate. They shall turn at a speed of not less than two hundred (200) r. p. m. and shall be enclosed except for the inlet and outlet.

When aggregates of different sizes are to be mixed, they shall be combined before being introduced into the mixing plant. When it is necessary to screen the aggregate on the project auxiliary storage bins with screening equipment shall be provided. The screens shall be designed, constructed, and operated so as to screen the aggregate to specified sizes and appropriate fractions as established by the engineer and as necessary to meet the job mix tolerances. The blending or mixing of different sizes of aggregates to obtain the proper gradation shall be obtained by the use of satisfactory equipment such as reciprocating feeders, volumetric feeders, or special belt feeders.

The heating apparatus to meet temperature requirements shall be suitably designed to heat the mixture to a temperature of from 130° F. to 220° F. The heating apparatus shall be capable of preparing aggregate to the full rated capacity of the paving plant and to meet the specification requirements.

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

An approved method shall be provided for measuring the correct amount of hydrated lime and for its induction into the mixer at the rate of not more than two (2) pounds of lime per ton of aggregate.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading, shaping, or finishing will be required to provide a surface which will comply with the requirements for smoothness contained herein.

Spreader boxes or suitable spreading equipment may be permitted. Dumping of the material from the rear of trucks into spreader boxes drawn by tractors will not be allowed.

(d) *Rolling Equipment.* (1) The steel-wheel rollers shall be of the self-propelled tandem or three-wheel type weighing not less than eight (8) tons and not more than ten (10) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the base material from sticking.

(2) The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the

engineer. The weight of the roller shall be increased as the rolling progresses to the maximum degree obtainable without detrimental results to the course being compacted.

215-4.3 PREPARATION OF MINERAL AGGREGATE.

The prepared aggregate for the mixture shall be conveyed into the main bin ready for mixing with the emulsified asphalt. The aggregate shall be at a temperature between 130° F. and 212° F., and shall not contain more than six (6) percent moisture. The moisture shall be reduced when necessary by drying or aeration before the aggregate is placed in the bin. When aggregates of different sizes are to be mixed, they shall be combined before being placed in the main plant bin. The combining of the aggregate shall be in a manner to meet the gradation requirements within the job mix tolerances.

All work involved in clearing and stripping pits and handling unsuitable material encountered shall be performed by the contractor at his own expense. The base material shall be obtained from pits or sources that have been approved. The material in the pits shall be excavated and handled in a manner that a uniform and satisfactory product shall be secured.

215-4.4 PREPARATION OF BITUMINOUS MIXTURE.

Before being delivered to the runway, the aggregate shall be mixed with the bituminous material at a central mixing plant. The mixture shall be prepared at a temperature between 130° F. and 212° F., as directed by the engineer.

The aggregate prepared, as prescribed above, shall be accurately measured and conveyed into the mixer. Lime, if necessary to correct hydrophilic characteristics, shall be added with the aggregate. If needed to control the set, the lime shall be added after the emulsion but prior to completion of the mixing.

The percent of moisture is definitely stipulated in Table No. 1 for the emulsified asphalt. The free water present in the aggregates shall be determined by suitable tests and, if found excessive or variable, shall be controlled and made uniform. No water shall be added before or during the mixing operation. The total moisture present shall not exceed six (6) percent, including that contained in the emulsified asphalt. This definitely establishes the moisture content in the final mix.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the engineer and introduced into the mixer. The mixing shall continue for such a period as may be necessary to uniformly coat all of the particles passing the No. 4 mesh sieve and to obtain a mixture homogeneous in character. Excessive mixing shall be avoided.

215-4.5 TRANSPORTATION AND DELIVERY OF THE MIXTURE.

The mixture shall be transported from the mixing plant to the point of use in pneumatic-tired vehicles having tight bodies previously cleaned of all foreign materials. When directed by the engineer, each load shall be covered with canvas or other suitable

material of sufficient size and thickness to protect it from weather conditions.

No loads shall be sent out so late in the day as to interfere with spreading and other necessary manipulation during daylight unless artificial light, satisfactory to the engineer, is provided.

Any mixed material arriving on the project which does not conform in every way to the specified requirements shall be wasted.

215-4.6 SPREADING AND LAYING. (a) *Preparation for Placing.* Immediately before placing the bituminous mixture, the existing underlying course shall be cleaned of loose or deleterious material by sweeping with a power-sweeper equipped with blower, supplemented by hand brooms if necessary, or as directed by the engineer.

The mixture shall be laid only upon an approved underlying course which is dry and only when weather conditions are suitable. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 50° F. or under unless so directed by the engineer. In event of sudden rains, no more mixture in transit shall be dumped into the spreading machine. All work shall stop and the mixture that has been spread but not compacted by rolling shall be allowed to dry out.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins. The elevations of the grade stakes or pins shall be checked immediately before placing of the mixture.

Placing shall commence at the point or points furthest from the mixing plant, and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed will not be permitted until the material has been compacted thoroughly in the manner specified.

Contact surface shall be painted with a thin uniform coat of emulsified asphalt just before the mixture is placed.

(b) *Machine Spreading.* Upon arrival the mixture shall be dumped into an approved mechanical spreader or other suitable approved devices and immediately spread thereby to the full width required. It shall be struck off in a uniform layer of such depth (not to exceed five (5) inches when compacted) that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate as far as possible the pulling and tearing of the bituminous material.

Placing and compaction of the bituminous mixture shall progress in sections. The mixture shall be placed in strips of a minimum width of ten (10) feet. To insure proper drainage, the spreading shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-

way slope. The six (6) inch strip adjacent to the area on which future material is to be laid shall not be rolled until such material has been placed, but shall not be left unrolled more than twenty-four (24) hours after being placed. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted as provided for the first width, except that rolling shall be extended to include the six (6) inches of the first width not previously compacted. Whenever the adjacent or second width cannot be placed within twenty-four (24) hours, the six (6) inch strip shall not be left unrolled. After the second strip has been placed and rolled, a sixteen (16) foot straightedge shall be used across the longitudinal joint to determine if the surface is to grade and contour.

(c) *Hand Spreading.* In limited areas where, on account of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impracticable the mixture may be spread by hand.

When hand-spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread and be distributed into place immediately by means of shovels. It shall be spread in a uniformly loose layer to the full width required and of such depth that, where the work is completed, it will have the required thickness and will conform to the grade and surface contour required.

(d) *Layers.* The base shall be constructed in a layer of not more than five (5) inches compacted thickness. When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

215-4.7 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, sufficient time shall be allowed to obtain proper aeration and curing. The mixture shall be thoroughly and uniformly compacted by pneumatic-tired rollers or other approved equipment followed by power-driven three-wheel or tandem rollers. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the other edge.

Initial rolling shall be done longitudinally, overlapping on successive trips by at least twelve (12) inches. Rolling shall continue until the mixture is of uniform texture and degree of compaction and is true to grade and cross section. The mixture shall not contain more than three and one-half (3½) percent moisture by weight at the time of final rolling. The surface shall be maintained during compaction by alternate blading and rolling as required or directed. Upon instruction from the engineer, the course shall be rerolled any time within two weeks after the mixture is laid. The mixture shall be subjected to diagonal rolling, crossing the lines of the first.

Alternate trips of the powered rollers shall be of slightly different lengths. The speed of these rollers shall at all times be slow

enough to avoid displacement of the mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes and of fresh mixture where required. Final rolling shall be done with powered rollers. Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant. Rolling shall proceed at an average rate not to exceed 350 square yards per hour per roller.

Rolling shall continue until a density is obtained which is at least ninety-four (94) percent of the maximum density obtainable on the same mixture if compacted in a laboratory using the standard Proctor Method with all aggregate in the bituminous mixture passing the $\frac{1}{2}$ -inch sieve. (Reference A. A. S. H. O. Method T-99 with mixture at a temperature of 140° F. placed in three layers with twenty-five (25) blows per layer.) Field tests shall be made at least twice daily.

To prevent adhesion of the mixture to the powered rollers, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to the application of the tack coat or surfacing shall be removed and replaced with fresh mixture which shall be compacted to conform with the surrounding area, all to be done at the expense of the contractor. Skin patching on an area that has been rolled shall not be allowed.

215-4.8 JOINTS. (a) *General.* The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the previously placed material for the full specified depth of the course. Joints shall be formed by cutting back of the previous day's run so as to expose the full depth of the course, and the exposed edge shall be given a light paint coat of asphalt if necessary. The fresh mixture shall be raked against the joint, thoroughly tamped with tampers, and rolled.

(b) *Transverse.* The placing of the course shall be as nearly continuous as possible. The roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued.

(c) *Longitudinal.* The placing of the course shall be in the manner as specified and so that the joint is exposed for the shortest period possible. The joint shall be placed so that it will not coincide with that in the subbase and will break joints by at least one (1) foot.

215-4.9 SHAPING EDGES. While the base is being compacted and finished, the contractor shall trim the edges neatly to line.

215-4.10 SURFACE TESTS. The finished surface shall not vary more than three-eighths ($\frac{3}{8}$) inch for the base course when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the centerline. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression by powered rollers, and any variation shall be corrected by removing or adding materials and continuing the rolling. After the completion of final rolling, the smoothness of the course shall again be checked, and the humps or depressions exceeding the specified tolerances or that retain water on the surface shall be corrected by removing the defective work and replacing with new material or by adding additional material as directed by the engineer and at the expense of the contractor.

215-4.11 SAMPLING BASE. For the determination of composition, compaction, and density of the base the contractor shall remove suitable size samples of the completed base. Samples for each day or fraction thereof, when mixtures are placed, shall be taken by the engineer. The contractor shall replace the base where samples are removed, and these replacements shall be installed by the contractor free of charge. After the samples have been removed they will be tested by the engineer for density and composition. If the deficiency in composition and density exceeds the limits of toleration from that specified, satisfactory corrections shall be made.

215-4.12 MAINTENANCE. The surface shall be continually maintained until the base course is accepted. Following the construction of the course, the contractor shall do such rolling and other maintenance work as is necessary to maintain the surface density and grades and to keep the surface clean of any foreign material. The engineer shall have full and specified authority to stop all hauling over the completed or partially completed base course when such hauling is causing damage or is tracking excessive foreign material onto the course.

215-4.13 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those

materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

For checking the adequacy of the equipment in use, inspecting the conditions and operation of the plant, for the verification of weights or proportions and character of materials and/or the determination and checking of temperatures being maintained in the preparation of the mixtures, the engineer or his authorized representatives shall have access at any time to all parts of the paving plant.

The contractor shall furnish vendor's certified test report for each carload or equivalent of emulsified asphalt shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

215-4.14 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

215-5.1 The tonnage of emulsified asphalt aggregate base course to be paid for shall be the number of tons of the approved bituminous mixture called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture or for the moisture within the limits of the specification.

215-5.2 The bituminous material and lime when used shall not be paid for separately but shall be included in the price bid for base course above, and shall be considered incidental to the price for this item.

BASIS OF PAYMENT

215-6.1 The quantities of emulsified asphalt aggregate base mixture, determined as provided in 5.1 and 5.2 above, shall be paid for at the contract unit price per ton in the bid schedule for base course, which price and payment shall constitute full compensation for preparing the underlying course; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping,

compacting, and rolling; for finishing; for improving unsatisfactory areas; for reconditioning the underlying course and shoulders; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; for all labor, equipment, tools, and incidentals necessary to complete the item, except any prime or tack coat.

Payment will be made under:

Item P-215-6.1 Emulsified Asphalt Aggregate Base Course—per ton.

ITEM P-216 MIXED IN-PLACE BASE COURSE

DESCRIPTION

216-1.1 This item shall consist of a base course composed of mineral aggregate and bituminous material, mixed in-place, constructed on the prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with line and grade established by the engineer.

216-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight, to be added to the aggregate shall be between the limits as set forth in the table. The exact percentage to be used shall be fixed by the engineer on the basis of preliminary tests and field sieve analysis of the aggregate furnished.

216-1.3 JOB MIX FORMULA. No work shall be started on the project, nor any mixture accepted therefor, until the contractor has submitted samples of the materials intended for use and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate and for bituminous cement. The material furnished shall conform to the approved job mix formula within the tolerances specified herein.

JOB MIX TOLERANCES

	<i>Plus or Minus</i>
Aggregate passing sieve No. 4 and larger.....	7 percent.
Aggregate passing Nos. 10, 40, and 80 sieves.....	5 percent.
Aggregate passing No. 200 sieve.....	2 percent.
Bitumen.....	0.5 percent.

MATERIALS

216-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, crushed slag, screenings, gravel, sand-gravel, sand or other natural, granular, or approved material having essentially the same qualities and meeting all the requirements when combined within the limits for gradation.

The aggregate shall be tough, durable, and sound. The coarse aggregate when tested in accordance with the Los Angeles Rattler Test, after five hundred revolutions, shall have a percent of wear of not more than fifty (50) according to the A. A. S. H. O. Method T-96. The dry slag shall weigh not less than sixty-five (65) pounds per cubic foot.

The portion of the material retained on a No. 4 mesh sieve shall be known as coarse aggregate; that portion passing a No. 4 mesh sieve shall be known as fine aggregate, and the material passing the No. 200 mesh sieve shall be known as filler. The composite material shall meet the requirements for one of the gradations given in Table 2 or 3 using A. A. S. H. O. Methods T-11 and T-27.

That portion of the fine aggregate, including any blended filler, passing a No. 4 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91; a liquid limit of not more than 25 as determined by A. A. S. H. O. Method T-89, and a maximum clay content by elutriation of six (6) percent.

The composite aggregate shall be free from vegetable matter, lumps or balls or clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material.

216-2.2 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregate shall conform to the grade, requirements and specifications as follows:

Refined tar, grade RT-6, RT-7, RT-8, RT-9, conforming to the requirements of A. A. S. H. O. Specification M-52.

The emulsified asphalt shall be homogeneous and of such character that it will mix with distilled water in all proportions and shall meet the requirements of Table 1:

TABLE 1.—Requirements for Emulsified Asphalt

Test requirements	A.A.S.H.O. test method	Limits
Viscosity, Saybolt Furol, at 77° F. secs.....	T-59	20-120
Residue at 325° F., percent.....	T-59	55- 65
Oil Distillate, by volume, percent.....		1- 3
Demulsibility: 50 ml. of 0.1 N CaCl ₂ , not less than, percent.....	T-59	30
Sieve Test, not more than, percent.....	T-59	0.05
Settlement 5 days, not more than, percent.....	T-59	5
Stone Coating Test.....	T-59	Shall pass
Sampling Material.....	T-40	-----

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F./77° F., not less than.....	T-43	0.96
Penetration at 77° F., 100 g., 5 secs.....	T-49	150-225
Soluble in Carbon Tetrachloride, not less than, percent.....	T-45	97
Ductility at 77° F., not less than, cms.....	T-51	60

The material shall not be cracked.

The base asphalt for the emulsified asphalt shall have a range of penetration at 77° F., 100 g., 5 secs., of 150-225. The mixture of emulsified asphalt and aggregate, after curing, shall develop no indication of re-emulsifying due to its coming in contact with moisture or water. The emulsified asphalt shall be of such stability that it will remain constant and uniform while being combined and mixed with the aggregates, and shall show satisfactory mixing properties when combined with the aggregates without balling up or becoming hard or tacky.

Coating test shall not show appreciable separation when emulsified asphalt is mixed with washed, dry, clean stone for three (3) minutes. The emulsified asphalt shall coat the stone thoroughly.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility. The asphalt shall be tested for cracked material prior to emulsification.

216-2.3 HYDRATED LIME. The hydrated lime shall meet the requirements of A. S. T. M. Designation C-6.

216-2.4 PORTLAND CEMENT. The Portland cement shall meet the requirements of A. A. S. H. O. Specification M-85.

COMPOSITION OF MIXTURE

216-3.1 GRADATION AND COMPOSITION. The mineral aggregate for the base course shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to one of the following gradations:

TABLE 2.—*Requirements for Gradation of Aggregate*

Sieve size	Percentage by weight passing (square openings)		
	A 2'' maximum	B 1½'' maximum	C 1'' maximum
2-inch.....	100		
1½-inch.....		100	
1-inch.....	55- 85	70- 95	100
¾-inch.....	50- 80	55- 85	70 -100
No. 4.....	30- 60	30- 60	35 - 65
No. 40.....	5- 30	5- 30	10 - 30
No. 200.....	0- 5	0- 5	0 - 5
Bitumen, percent.....	3- 5	3- 5	3½- 5½

TABLE 3.—*Requirements for Gradation of Aggregate*

Sieve size	Percentage by weight passing (square openings)
	D
1½-inch.....	100
¾-inch.....	92-100
No. 4.....	80-100
No. 10.....	65- 95
No. 40.....	25- 70
No. 80.....	10- 50
No. 200.....	0- 8
Bitumen, percent.....	4½- 8

The gradations in these tables represent the limits which shall determine suitability of aggregate for use from the sources of supply. The gradations of the composite mix shall be within the limits designated in the tables, shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

When sand and emulsified asphalt are used for the base course, a sample mixture shall be made and tested. After the sand and emulsified asphalt has been thoroughly mixed and spread in a thin layer, the mixture shall be dried in a drying oven to constant weight at 140° F. The mixture shall be tamped into a cylinder in thin layers. After the mold is tamped full it shall be placed in a compression machine and subjected to a pressure of about 2,000 pounds per square inch. After compaction the mold shall be placed in an oven for at least two (2) hours to bring the temperature to 140° F. It shall be removed from the oven, placed in a 140° F. water bath, and tested in the same machine described in CAA Test T-607. The mixture shall have a bearing value of one hundred (100) pounds per square inch or more to be acceptable.

When called for in the proposal, Portland cement or lime shall be added to the emulsion mix to control the consistency or the set of the mixture.

The percentage of bituminous material shown is by weight of the dry aggregate.

CONSTRUCTION METHODS

216-4.1 WEATHER LIMITATIONS. The base course shall be constructed and operations shall be carried on only when the surface is dry, when the atmospheric temperature is above 45° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

216-4.2 EQUIPMENT. (1) *General.* All methods employed in performing the work and all equipment, tools, and other plant and machinery used for handling materials and executing any part of

the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(2) *Traveling Plant Mixer.* The traveling plant shall be self-propelled or tractor-drawn and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the subgrade or subbase course. The device for picking up the aggregates from the windrow shall be such that it will take up the loose material and leave the underlying course clean without damage. Plants equipped for drying the aggregates before adding the bituminous material shall be so constructed as not to allow a loss of aggregate or segregation. The equipment for proportioning the aggregate and bituminous material shall accurately measure the specified amounts of material for the mix while the machine is in operation. The plant shall be capable of thoroughly combining the aggregates and bituminous material into a mixture of uniform color with all the particles completely coated, and shall also be capable of depositing the processed mixture on the subgrade or subbase.

Approved methods shall be provided for accurately controlling the correct amount of filler, Portland cement, or lime, and for the induction of same into the mixture at the specified time, when these materials are required.

(3) *Spreading Equipment.* Blade graders for windrowing aggregate and for spreading processed material shall be self-powered or tractor-drawn. The grader shall have a wheel-base of not less than fifteen (15) feet, shall have a blade not less than ten (10) feet long, and be equipped with wheels of sufficient width to prevent excessive rutting.

If aeration is not necessary prior to compaction, the mixed material may be placed and spread by a mechanical spreader and finisher.

(4) *Rolling Equipment.* (a) The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer. The weight of the roller shall be increased as the rolling progresses to the maximum degree obtainable without detrimental results to the course being compacted.

(b) The steel-wheel rollers shall be of the self-propelled, tandem, or three-wheel type, weighing not less than five (5) tons and not more than ten (10) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surfaces. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the base material from sticking.

216-4.3 PREPARATION OF UNDERLYING COURSE.

The underlying course, upon which the base course is to be placed, shall be properly prepared, smooth, and fully compacted. It shall be cleaned of all loose material and deleterious matter, and when tested with a sixteen (16) foot straightedge shall show no deviation in excess of three-eighths ($\frac{3}{8}$) inch.

216-4.4 PLACING MINERAL AGGREGATE. If borrow or foreign aggregate is used, it shall be transported to the site of paving in trucks equipped with pneumatic tires. Both speed and load shall be regulated by the engineer in order to reduce the possibility of damage to the existing surface. The aggregate, existing or otherwise, shall be formed in windrows in such quantity and proportions as to provide sufficient total aggregate, conforming with the specified gradation, to produce a finished base course of the specified compacted thickness. The contractor may proportion the amount of aggregate in the windrow by weighing with suitable equipment, or by using any other methods or devices which will be equally as effective as weighing equipment, in placing the amount of total aggregate necessary to satisfy the yardage requirements for the area to be covered. After the proportions of aggregate have been adjusted, if required to meet the gradation, the total loose aggregate shall be thoroughly mixed to the satisfaction of the engineer. It shall then be bladed into windrows of uniform cross section for the final measurement and sampling for gradation adjustment. The formation of windrows in advance of mixing shall be limited so as to prevent water from standing on the subgrade or ponding between windrows in case of rain.

216-4.5 MOISTURE CONTENT OF AGGREGATE. Immediately prior to bituminizing, the aggregate to be treated shall be tested for moisture. If the moisture content is in excess of the maximum allowable percentage, the aggregate shall be turned by blades or disc harrows, or otherwise aerated, until the moisture content is reduced. The prepared aggregate shall then be windrowed as before or spread uniformly for mixing.

216-4.6 MIXING. The aggregate, windrowed and prepared as specified above, shall then be mixed with the bituminous material by means of the traveling mixing plant and deposited ready for spreading.

The Portland cement or lime shall be added during the mixing procedure at the time and in the amounts as required by the engineer.

The quantity of bituminous material as calibrated for continuous mixer shall be determined by the engineer, and introduced into the mixer. The mixing shall continue for such period as is necessary to coat all of the particles and obtain a homogeneous mixture.

Before spreading, the mixture shall be examined by the engineer who shall determine whether the mixing is complete and satisfactory. Should the mixture show an excess, deficiency, or uneven distribution of bituminous material, the unsatisfactory condition shall be corrected by the addition of the required aggregate or bituminous

material and by remixing. If necessary, the material shall be harrowed or disced and all compressed masses of material broken up. No mixing or spreading shall be done except when authorized by the engineer.

When approved by the engineer, the material may be mixed by a rotary-tiller type of mixer. When this or similar equipment is allowed, the base material shall be prepared and spread in-place in a uniform layer and to the proper thickness and contour. The mixing shall be thorough, with the specified bitumen content, and to the depth designated. The application of bituminous material shall be by distributor or spray-bar attachment. All applicable requirements included herein shall govern the mixing. When approved, mixing equipment which combines mixing and placing in one operation may be used.

216-4.7 SPREADING AND FINISHING. (1) *General.* Spreading shall not be started until the subgrade or subbase has been properly prepared, compacted, and approved by the engineer.

When in-place materials or aggregates are used in the base course mixture, the coarse aggregate between the 2-inch sieve and the 1½-inch sieve shall not exceed five (5) percent. Any material that will not pass the 2½-inch sieve shall be culled out and removed from the base course.

Grade control between the edges of the runway shall be by means of grade stakes or steel grade pins placed in lanes parallel to the centerline of the runway and at intervals sufficiently close that string lines may be stretched between the stakes or pins.

When practicable and to protect the subgrade and to insure proper drainage, the mixing and spreading of the base shall begin along the centerline of the runway, or taxiway on a crowned section, or on the high side of the pavement with a one-way slope.

The base course shall not be placed in a layer thicker than four (4) inches compacted thickness. Each layer shall be spread, finished, and compacted as described herewith before an additional layer is placed.

(2) *Spreading and Blade Finishing.* The mixture shall be placed in lanes parallel to the centerline of the runway and ending each day's run for the full width of the lane.

After the mixing has been completed, the mixed material shall be spread to the required width and depth by a self-powered or tractor-drawn blade grader, mechanical spreader, or other approved method. In spreading from a windrow, care shall be taken to prevent cutting into the underlying course. If necessary to prevent such cutting, a layer of the mixture approximately one-half (½) inch thick shall be left at the bottom of the windrow. The mixture shall be spread and cured in thin layers. The surface shall be continually bladed, disced, and dragged, if necessary, until a smooth uniform surface, true to line, grade, and cross section, has been developed. Should the mixture show an excess, deficiency, or uneven distribu-

tion of bituminous material, such unsatisfactory conditions shall be corrected.

After the base course material has been mixed, spreading shall not be started if threatening weather is apparent. The engineer shall have control of the spreading, aeration, and rolling procedure, and no spreading shall be done without his consent. The contractor shall regulate his operations in a scheduled manner by mixing only such amounts that can be spread, aerated, and compacted within relatively short periods. Those areas which become wet shall be dried and remixed with bituminous material when directed. The remixing, including application of the bituminous material, shall be handled in such manner as to insure thorough and uniform coating of the aggregate. Any mixture that is unsatisfactory because of becoming wet or remains unsatisfactory after remixing shall be removed. Prior to final compaction, the moisture content of the base material shall have been reduced by aeration to four (4) percent or less.

216-4.8 COMPACTION OF MIXTURE. Aeration after mixing and prior to rolling shall be continued until the mixture is in suitable condition for proper compaction. After each layer has been placed and cured, it shall be thoroughly and uniformly compacted by rollers, as specified. Blading shall continue during the rolling only if so ordered by the engineer. Initial rolling shall be done with pneumatic rollers.

Initial rolling shall be done longitudinally, overlapping on successive trips by at least twelve (12) inches. Alternate trips of power rollers shall be of slightly different lengths. Rolling shall continue until the surface is of uniform texture and degree of compaction and is true to grade and cross section. Final rolling shall be done with the power rollers. Rolling shall continue until a density is obtained which is at least ninety-five (95) percent of the maximum density obtainable on the same mixture if compacted in a laboratory using the standard Proctor Method with all aggregate in the bituminous mixture passing the $\frac{1}{2}$ -inch sieve. (Proctor Method, A. A. S. H. O. Method T-99 with mixture at a temperature of 140° F. placed in three layers with twenty-five (25) blows per layer.)

The speed of the rollers shall at all times be slow enough to avoid displacement of the mixture. Any displacement occurring as a result of the reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes and of fresh mixture where required. Sufficient rollers of the designated types shall be furnished to adequately handle the rate of spreading and aeration of the mixture.

Upon instructions from the engineer, the course shall be rerolled any time within two (2) weeks after it is laid and shall be subjected to diagonal rolling, crossing the lines of the first. If necessary to prevent adhesion of the mixture to the power roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be in good condition and shall

be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to acceptance, shall be removed and replaced, at the expense of the contractor, with fresh mixture which shall be compacted to conform with the surrounding area. Skin patching on an area that has been rolled shall not be allowed. Any mixture remaining unbonded after rolling shall be removed and replaced.

216-4.9 JOINTS. The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the previously placed base material for the full specified depth of the course. A straightedge shall be used across all joints to test and to insure grade and contour of the surface.

216-4.10 SHAPING EDGES. While the base is being compacted and finished, the contractor shall trim the edges neatly to line.

216-4.11 SURFACE TESTS. The finished surface shall not vary more than $\frac{3}{8}$ -inch for the base course when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the centerline. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression by powered rollers and any variation shall be corrected by removing or adding materials and continuing the rolling.

216-4.12 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch, the contractor shall correct such areas by scarifying, adding satisfactory base mixture, rolling, reshaping, and finishing in accordance with these specifications. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

216-4.13 MAINTENANCE. The surface of the base course shall be maintained in its finished condition until any surface course or surface treatment provided in the contract is placed thereon, and the contract is completed and accepted.

216-4.14 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted

and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish materials subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

The contractor shall furnish vendor's certified test report for each carload or equivalent of bituminous material shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

216-4.15 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made and certified weigh bills when materials are received in any other manner of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of freight and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

216-5.1 The unit of measurement for mixed in-place base course laid shall be the square yard. The yardage to be paid for shall be the square yards of base course completed and accepted in accordance with the plans and specifications, or as directed by the engineer.

216-5.2 The unit of measurement for the bituminous material shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F. in accordance with a coefficient of expansion of 0.00025 per degree F. for emulsified asphalt or in accordance with A. S. T. M. Designation D-633 for tar.

BASIS OF PAYMENT

216-6.1 The quantities of mixed in-place base mixture and bituminous material, determined as provided in 5.1 and 5.2 above, shall be paid for at the respective contract unit prices in the bid schedule, which prices and payment shall constitute full compensation for preparing subgrade or subbase; for furnishing, handling, mixing,

manipulating, and placing all materials, including any sand stabilizer; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas, including remixing when necessary; for reconditioning the underlying course and shoulders; for furnishing samples; and for labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-216-6.1 Mixed In-Place Base Course—per square yard.

Item P-216-6.1 Bituminous Material—per gallon or per ton.

ITEM P-217 AGGREGATE-TURF PAVEMENT

DESCRIPTION

217-1.1 This item shall consist of an aggregate-turf pavement composed of a base course of soil-bound crushed stone, soil-bound gravel, or soil-bound sand, or fine aggregate, and a seed bed of suitable soil or combination of soil and aggregate, constructed on a prepared subgrade or a previously constructed underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with the lines and grades established by the engineer.

This item may include the furnishing and applying of fertilizer, lime, top soil, or other plant nutrients; the furnishing and planting of seed; and the furnishing and spreading of mulch. When any of these turfing materials are required the quality, quantity, and construction methods shall be in accordance with applicable CAA Turf Specifications. When turf is to be established, the seed bed soil or topsoil shall be a natural friable loam, possessing characteristics of the best locally obtainable soils which can produce at least a fairly heavy growth of crops, grass, or other vegetation.

The prepared composite mixture of aggregates used for the base course shall be type A, type B, or stabilizer aggregate mixed with in-place materials, whichever is called for in the bid schedule, provided that when the type is not so fixed the type or types shall be selected by the engineer.

MATERIALS

217-2.1 STABILIZED MIXES. The type or types of base course stabilized mixtures designated shall conform to the following requirements:

Type A—The materials for this type shall be composed of natural or artificial mixtures of clay or soil binder and gravel, stone or sand, or other aggregate, as screenings proportioned to meet the requirements hereinafter specified. The aggregate retained on a No. 4 mesh sieve shall be composed of hard, durable, particles and shall be free from injurious or deleterious substances.

Type B—The material for this type shall consist of natural or artificial mixtures of gravel, stone, or slag and soil mortar so proportioned as to meet all the requirements hereinafter specified. The coarse aggregate shall consist of clean, hard, durable particles of crushed or uncrushed gravel, stone, or slag, free from soft, thin, elongated or laminated pieces, and vegetable or other deleterious substances. It

shall be hard and durable enough to resist weathering, traffic abrasion, and crushing. Shales and similar materials that break up and weather rapidly when alternately frozen and thawed, or wetted and dried, shall not be used. The soil mortar shall be that portion passing the No. 10 mesh sieve, and shall be composed of soil binder and granular material such as stone or slag screenings or sand.

The prepared composite mixture used shall meet the applicable gradation requirements as follows:

TABLE 1.—*Requirements for Gradation of Mixture*

Sieve designation	Percent by weight passing square mesh sieves		
	Type A	Type B	
2-inch.....			100
1-inch.....	100	100	70- 95
¾-inch.....		70-100	
No. 4.....			40- 70
No. 10.....	60-100	40- 70	32- 60
No. 20.....	50- 90		
No. 40.....	40- 75	20- 45	20- 40
No. 200.....	12- 30	10- 20	10- 20

In all cases the fraction passing the No. 200 mesh sieve shall be less than two-thirds of the fraction passing the No. 40 mesh sieve. The fraction passing the No. 40 mesh sieve shall have a liquid limit not greater than 30 and a plasticity index not greater than 8. The fine aggregate and any fine soil particles used as a binding material shall be such that they will produce the required plastic properties and characteristics necessary for a stable soil-aggregate course after mixing and compacting.

217-2.2 STABILIZER AGGREGATE. When called for in the bid proposal, stabilizer aggregate meeting the gradations as required herewith shall be placed upon the existing soil or base course in the quantity per square yard as specified. The aggregate shall be uniformly blended with the soil or base course material to the depth required or as shown on the plans. The aggregate shall consist of crushed stone, crushed or uncrushed gravel, or crushed slag, and shall have a percent of wear of not more than 60 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test). The aggregate shall be free from soft, thin, elongated, or laminated pieces, disintegrated material, or other deleterious substances.

When approved or included in the proposal, screenings or coarse sand may be used for stabilizer aggregate. The gradation shall be as shown in the table.

Where sands as existing subgrade or base require stabilization, this may be secured by the addition of clays or limerock. The operations

of spreading and mixing shall be handled as given under construction methods.

The stabilizer aggregate shall meet the gradation requirements as follows:

TABLE 2.—Requirements for Gradation of Stabilizer Aggregate

Sieve designation	Percent by weight passing square mesh sieves		
	Size K	Size L	Screenings or coarse sand
2-inch.....		100	
1½-inch.....	100		
1-inch.....	90-100		
½-inch.....		0-15	100
No. 4.....	20- 50		85-100
No. 10.....	0- 10		
No. 100.....			0- 30

If the aggregate becomes segregated prior to placing, it shall be remixed until gradation is as required.

217-2.3 MOISTURE CONTENT. The materials of Type A, B, or the mixture of stabilizer aggregate or binder with in-place materials shall have sufficient moisture at the time of rolling to insure the required compaction.

CONSTRUCTION METHODS

217-3.1 OPERATION IN PITS. All work involved in clearing and stripping pits including handling unsuitable material encountered shall be performed by the contractor at his own expense. The base or binder material shall be obtained from pits or sources that have been approved. The material in the pits shall be excavated and handled in a manner that a uniform and satisfactory product shall be secured.

217-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The powered roller shall be of the three-wheeled type, weighing not less than five (5) tons nor more than eight (8) tons. The roller shall have a rear-wheel compression of not less than 250 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The tamping roller shall consist of metal rollers, drums, or shells surmounted by metal studs with tamping feet projecting not less than six (6) inches from the surface of the roller, drum, or shell. The area of each tamping foot shall be from five (5) to nine

(9) square inches. Each roller shall consist of two sections and the length of each section shall be not less than four (4) feet. When empty, the roller shall produce at least 120 pounds per square inch of area of tamping feet in contact with the ground. The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and operating power unit shall meet the approval of the engineer.

Other equipment may be used for compacting and consolidating the base course, upon approval of the engineer. Such equipment shall be routed over the area being compacted, and shall be operated until the required density is obtained.

Equipment for spreading and shaping shall consist of spreader boxes having strike-off templates, or screeds, or of other spreading devices which will place the required quantity of base material, stabilizer aggregate, or binder in a uniform layer with a minimum of segregation.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The processing equipment shall be designed, constructed, operated, and of such capacity so as to thoroughly mix all materials and water in the proportions as directed to produce a base course of the gradation and consistency required.

217-3.3 PREPARING SUBGRADE. Before any base course material is placed, the subgrade or underlying course shall be prepared and conditioned as specified for that course. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the underlying course and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

217-3.4 PLACING MATERIALS. (a) When all new material is called for, it shall be placed on the prepared course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material on the prepared and completed layer shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer will have the re-

quired thickness. It shall be the charge of the contractor that the required amount of approved material is delivered in each 100-foot station. The material shall be spread with approved equipment. When combining materials from different sources is necessary, such combining may be done either at the pits in a processing plant prior to delivery of the material, or on the course by the proper proportions of each material being deposited in successive spreadings as will give the required gradation and thickness of layer. If the combining is done on the course, the mixing shall be as specified hereinafter.

(b) When blending of new material with material on the existing surface is called for, the existing surface shall first be scarified lightly and bladed to uniform grade and to cross section shown on the plans. After blading and when necessary, the existing surface shall be further scarified and/or pulverized to provide sufficient loose material of the required depth to be mixed with the added material. Over the prepared material in-place shall be spread the new material of the gradation called for and in the amounts as directed by the engineer.

217-3.5 SPREADING AND MIXING. (a) Materials that have been mixed and processed in a processing plant at the pits, or elsewhere, shall be delivered and spread by specified equipment to the required depth.

(b) Following the placing of the required quantities of materials being combined on the base course, the total base material shall be thoroughly pulverized and mixed by means of approved rotary-pulverizing mixers. The moisture content of the aggregate and soil binder shall be as directed by the engineer, and shall be that necessary to secure thorough mixing and the required compaction. The mixing shall produce a homogeneous mass of the specified gradation and soil characteristics to form a base course of the desired qualities. When the mixing is completed the material shall be spread in a uniform layer which, when compacted, will meet the requirements for thickness and typical cross section.

217-3.6 ROLLING. Immediately following final spreading, the material shall be compacted to full width by rolling with approved compacting equipment. Rolling shall progress gradually from the sides to the center of the lane under construction, or from one side toward previously placed material, and shall continue until all the surface has been rolled and compacted. Rolling shall continue until the base material has been compacted from seventy (70) to ninety (90) percent density as determined by the standard Proctor Density Test, A. A. S. H. O. Method T-99, and as designated in the proposal. Any irregularities or depressions that develop under rolling shall be corrected by loosening the material at these places and adding or removing materials until the surface is smooth and uniform. The base material shall be at a satisfactory moisture content at the time of rolling to secure the required compaction.

Part of the compaction shall be secured by pneumatic rollers. Final rolling shall be done by power rollers. All rollers shall be handled by experienced rollermen.

217-3.7 SURFACE TEST, THICKNESS, AND MAINTENANCE. The surface of the completed base course shall not show any deviation in excess of one-half ($\frac{1}{2}$) inch when tested with a sixteen (16) foot straightedge applied parallel to and at right angles to the centerline of the base. Any deviation in excess of this amount shall be corrected by loosening, adding, or removing material, reshaping, and recompacting by sprinkling and rolling.

The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 500 square yards. When the base deficiency is more than one-half ($\frac{1}{2}$) inch it shall be corrected. The contractor shall replace, at his expense, the base material where borings are taken for test purposes.

The surface of the base course shall be maintained and kept in a well-drained condition until the construction of another course. Sprinkling, blading, and rolling shall be performed when necessary to prevent the base material from becoming unbonded.

217-3.8 TURF-SURFACING. Following the construction of the soil-aggregate base, the contractor shall prepare the seed bed for the establishment of the turf. If topsoil is to be placed, the surface of the base course shall be loosened slightly as directed by the engineer. If seeding is to be done without topsoiling, the surface of the base shall be loosened sufficiently to prepare a seed bed. This can be accomplished by discing, harrowing, rotary-tilling, or other approved methods, and should be to a depth of not less than one (1) inch nor greater than three (3) inches. Any topsoil shall be spread to the depth as required. The seed bed preparation, applying lime, fertilizer and water, seeding, rolling and mulching, shall be performed in accordance with the specification requirements.

METHOD OF MEASUREMENT

217-4.1 The quantities of soil-aggregate base course to be paid for shall be the number of cubic yards of base course material placed, bonded, and accepted in the completed base course. The quantity shall be measured in final position based on depth tests or cores or by means of average end areas on the completed work.

The quantities of the stabilizer aggregate to be paid for shall be the number of tons of aggregate furnished, placed, and accepted in the completed base course.

The quantities of stabilizer binder to be paid for shall be the number of cubic yards of binder furnished, placed, and accepted in the completed base course. Measurement shall be made in the vehicles at the point of delivery.

When approved materials in-place are utilized in the base course, the preparation and incorporation of other materials in the base mix-

ture shall be measured as a conditioning and mixing operation. The yardage to be paid for shall be the number of square yards of such material prepared and incorporated in the mix, completed, and accepted.

The yardage of topsoil to be paid for shall be the number of cubic yards of topsoil removed, placed, and spread in the accepted work.

The tonnage of lime and fertilizer to be paid for shall be the number of tons, or in one hundred (100) pound sacks, of the quality called for in the bid schedule, furnished, incorporated, and accepted.

The acreage of seeding to be paid for shall be the number of acres and tenths thereof, measured horizontally, seeded, and accepted.

The units of watering for planting to be paid for shall be the number of 1,000-gallon units of water measured by approved water meter or in the vehicle at the point of delivery, furnished and applied as specified or ordered.

The acreage of mulching to be paid for shall be the number of acres and tenths thereof, measured horizontally, mulched, and accepted.

BASIS OF PAYMENT

217-5.1 The quantities of soil-aggregate base course, as provided above, shall be paid for at the contract unit price bid per cubic yard of the type and gradation called for in the bid schedule, which price and payment shall constitute full compensation for furnishing, loading, hauling, and placing the material; for mixing, spreading, and rolling; for refilling test holes; and for all labor, equipment, tools, water, and incidentals necessary to complete the base.

The tonnage of stabilizer aggregate measured, as provided above, shall be paid for at the contract unit price bid per ton, which price and payment shall be full compensation for furnishing, weighing, hauling, and placing all materials; and for all labor, equipment, tools, and incidentals necessary for the work.

The yardage of stabilizer binder, determined as provided above, shall be paid for at the contract unit price bid per cubic yard, which price and payment shall be full compensation for furnishing, measuring, hauling, and placing all material; and for all labor, equipment, tools, and incidentals necessary for the work.

The yardage of conditioned material, measured as provided above, shall be paid for at contract unit price bid per square yard, which price and payment shall be full compensation for all scarifying, mixing, watering, remixing, machining, compacting, shaping, and manipulation; and for all labor, equipment, tools, and incidentals necessary for the work.

The yardage of topsoil, determined as provided above, shall be paid for at the contract unit price bid per cubic yard, which price and payment shall be full compensation for furnishing, removing, hauling, placing, and spreading the topsoil; and for all labor, equipment, tools, and incidentals necessary to complete the work.

The tonnage of lime and fertilizer, measured as determined above, shall be paid for at the respective contract unit price bid per ton of lime or per ton of fertilizer, which price and payment shall be full compensation for furnishing, hauling, and placing; and for all labor, equipment, tools, and incidentals necessary to complete the work.

The acreage of seeding, measured as determined above, shall be paid for at the contract unit price bid per acre, which price and payment shall constitute full compensation for any necessary grading, tillage, furnishing, and sowing the seed; for compacting; for repairing and maintenance; and for all labor, equipment, tools, and incidentals necessary to complete the work.

The units of watering for planting, measured as determined above, shall be paid for at the contract unit price bid per unit, which price and payment shall be full compensation for furnishing, hauling, and applying; and for all labor, equipment, tools, and incidentals necessary to complete the work.

The acreage of mulching, measured as determined above, shall be paid for at the contract unit price bid per acre, which price and payment shall be full compensation for furnishing, placing, and anchoring the materials; for maintenance; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- Item P-217-5.1 Soil Aggregate Base Course—per cubic yard.
- Item P-217-5.1 Stabilizer Aggregate—per ton.
- Item P-217-5.1 Stabilizer Binder—per cubic yard.
- Item P-217-5.1 Conditioning Operation—per square yard.
- Item P-217-5.1 Topsoil—per cubic yard.
- Item P-217-5.1 Lime—per ton.
- Item P-217-5.1 Fertilizer—per ton.
- Item P-217-5.1 Seeding—per acre.
- Item P-217-5.1 Watering—per 1,000-gallon unit.
- Item P-217-5.1 Mulching—per acre.

RIGID BASE COURSES

ITEM P-301 SOIL CEMENT BASE COURSE

DESCRIPTION

301-1.1 This item shall consist of constructing a six (6) inch base course by uniformly mixing together soil, Portland cement, and water; of spreading, shaping, and compacting the mixture in accordance with the requirements of this specification and in conformity with the dimension and typical cross section shown on the plans and to the lines and grades established by the engineer.

Runways, taxiways, or aprons may be built in a series of parallel lanes twenty (20) to thirty (30) feet wide. Longitudinal construction joints shall be formed by temporary six (6) inch by six (6) inch wooden side forms, or their equivalent, unless otherwise specified, set firmly to the required grade to permit thorough compaction and finishing operations to proceed along their length. The side forms shall be removed before the adjoining lanes are constructed.

It is the purpose of this specification to so combine cement, soil, and water as to produce a base mixture which can be satisfactorily spread, compacted, and shaped as herein specified and which will have the desired strength and durability.

MATERIALS

301-2.1 MATERIALS. The materials used in this work shall meet the following requirements:

(a) *Portland Cement.* Portland cement shall be a standard brand, and shall conform to the standard requirements of A. S. T. M. Designation C-150. The expansion of samples tested for soundness in the autoclave shall not exceed one-half ($\frac{1}{2}$) of one percent.

Contractors may at their option use bulk cement, subject to approval by the engineer of the apparatus for handling, weighing, and applying the cement, and subject to the work being done to the entire satisfaction of the engineer in every way.

(b) *Water.* The water for base course shall be clean, clear, and free from injurious amounts of sewage, oil, acid, strong alkalis, or vegetable matter; it shall be free from clay or loam. If the water is of questionable quality, it shall be tested in accordance with the requirements of A. A. S. H. O. Method T-26.

(c) *Soil.* The soil for this work shall consist of selected materials on the proposed airport site or selected materials from other sources, uniform in quality and gradation, and meeting the approval of the engineer. The soil shall be free of roots, sod, weeds, and stones of a greater dimension than two and one-half (2½) inches. The soil shall not contain lumps and shall be in a condition which can be readily mixed with cement and water.

LABORATORY SOIL TESTS AND QUANTITY OF CEMENT

301-3.1 LABORATORY SOIL TESTS. Prior to base course construction, laboratory tests of soils existing on the airport site, or selected material from other sources proposed for use as base, shall be made to determine the quantity of cement required for satisfactory results. Satisfactory materials for this purpose shall be obtained from an approved source as directed.

CONSTRUCTION METHODS

301-4.1 WEATHER LIMITATIONS. Base course shall be constructed and operations shall be carried on only when the atmospheric temperature is above 40° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

301-4.2 OPERATION AT PITS. All work involving in clearing and stripping pits, including the handling of unsuitable material encountered, shall be performed by the contractor. The contractor shall notify the engineer sufficiently in advance of the opening of any designated pit to permit staking of boundaries at the site, and to take elevations and measurements of the ground surface before any material is produced; also to permit the engineer to take samples of the material for tests to determine its quality and gradation, and to prepare a preliminary design of base mixture.

In order to prevent fluctuations in the gradation, the equipment used and the methods employed shall provide for taking material from a face or slope, extending the full depth of the designated excavation, and in such a manner as to provide a uniform supply of material.

301-4.3 EQUIPMENT. All methods employed in performing the work and all equipment, tools, other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

The powered roller shall be of the three-wheeled or tandem type, weighing not less than eight (8) tons. The roller shall have a rear-wheel compression of not less than 300 pounds per linear inch of tire width and shall be equipped with adjustable scrapers. The tamping roller shall consist of metal rollers, drums, or shells surmounted by

metal studs with tamping feet projecting not less than six (6) inches from the surface of the roller, drum, or shell. The area of each tamping foot shall be from five (5) to nine (9) square inches. Each roller shall consist of two sections, and the length of each section shall be not less than four (4) feet. When empty, the roller shall produce at least 120 pounds per square inch of area of tamping feet in contact with the ground. The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

Road machines shall weigh not less than three (3) tons, shall have a wheel base not less than fifteen (15) feet, and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers. Motor patrol may be used in lieu of a road machine.

Provision shall be made by the contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The processing equipment shall be designed, constructed, operated, and of such capacity so as to thoroughly mix the soil, cement, and water to produce a mixture that is homogeneous, uniform, and of the consistency required for compaction.

(a) A series of equipment for processing shall consist of a rotary tiller supplemented by discs, harrows, plows, water distributors, and cement distributors. The cement may be distributed by hand or by mechanical methods.

(b) The processing machine shall consist of a unit which combines pulverizing, blending, liquid application, and complete mixing with a single pass. The unit shall be supplemented by cement distributors. The cement may be distributed by hand or by mechanical methods.

(c) The traveling plant of the windrow type shall be self-propelled or tractor-drawn and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on wheels or tread equipment of such type that when loaded to capacity it will not rut or damage the underlying course. The device for picking up the soil from the windrow shall be such that it will take up the loose material and leave the course clean without damage. The equipment for proportioning the water shall accurately measure the specified amount for the mix while the machine is in operation. The plant shall be capable of thoroughly mixing the soil, cement, and water and of depositing the processed base mixture at the consistency required.

301-4.4 FORMS. When forms are required they may be of wood or of metal and shall be placed to line and grade as staked by the engineer. Wood forms shall have a thickness of not less than that of a commercial six (6) inch timber, shall have a height equal to the compacted depth of the base, and shall be not less than twelve (12)

feet in length. All form lumber shall be of good quality timber, straight, well-seasoned, clean, and free from defects which would impair its usefulness. Forms becoming warped, split, worn, or otherwise defective shall be discarded.

Steel forms shall be of a section commonly required for Portland cement concrete pavement. They shall be of a depth at least equal to the edge thickness of the work prescribed. They shall be straight and free from warp. The minimum length of section of steel form shall be ten (10) feet.

When directed by the engineer, side forms will not be required. In such cases the spreading equipment and supply of base mixture shall be such as will permit the continuous and satisfactory spreading of material for one- or two-lane construction, compacting it to the proper thickness and contour as required.

301-4.5 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started. Any ruts or soft, yielding places that appear by reason of improper drainage conditions, or hauling, or from any other cause, shall be corrected and rolled until firm before the base course is placed thereon.

Grade control between the edges of the runways shall be by means of grade stakes, steel pins, or forms placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines or check boards may be placed between the stakes, pins, or forms.

To protect the subbase and to insure proper drainage, the spreading of the base shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope.

301-4.6 PREPARING SOIL. The soil for treatment consisting of either the natural material existing in-place or selected material from approved sources shall be prepared and placed in accordance with the requirements and with the type of equipment that will be used for processing. Selected material from outside sources shall be transported to the site of construction and either placed in windrows or spread in layers on the prepared underlying course. The depositing and spreading of the material shall commence where designated and shall be in lanes in a uniform layer without segregation to such loose depth that when processed and compacted the base will have the required thickness. It shall be the charge of the contractor that the required amount of material is delivered in each 100-foot station. The material shall be spread by spreader boxes, moving vehicles equipped to distribute material, or other approved methods. If travel plant method is used, the material shall be placed in windrows parallel to the centerline of the runway or taxiway. Sufficient quantity shall be placed to provide a base course of the required thickness when compacted. The windrow shall be shaped to a uniform section and left undisturbed until measuring and sampling are complete.

The soil existing in-place or spread in layers, shall be scarified, bladed, disced, and dragged when necessary until a smooth, uniform, surface is obtained true to line, grade, and cross section, and in condition for mixing.

301-4.7 APPLICATION OF CEMENT. The engineer shall determine and have available the approximate proportions of cement, soil, and water to be used for the proposed supply of soil. Attention is called here to the basis of payment, paragraph 6.2, which provides that the cement will be paid for separately at the contract price per barrel.

On the soil prepared as described above shall be spread the specified quantity of Portland cement required for the treatment for the full depth of the base course. The cement shall be uniformly spread over the surface or on the windrow in one operation in an approved manner. If any of the machines used for mixing are equipped for proportioning the cement, it shall be added to the soil in the proper amount before mixing. No equipment except that used in spreading and mixing will be allowed to pass over the freshly spread cement until it is mixed with the soil.

301-4.8 MIXING. Immediately after the cement has been distributed, it shall be mixed with the loose soil for the full depth of the treatment. Care shall be exercised that the cement is not mixed with soil below the desired depth. Mixing shall be accomplished with the equipment specified. When the rotary-tiller type equipment is used, the cement and soil shall first be mixed dry, with at least two passes of the equipment and as many additional passes as are required to obtain a thorough, uniform, and intimate mixture. With the other types of approved equipment the soil, cement, and water shall be thoroughly mixed with one pass of the equipment.

Water shall be incorporated in the mix in the amount directed by the engineer and under such conditions as will permit accurate control of the amount of water added. Attention is called to the necessity of a dry mix to permit placing and compacting as herein specified. The mixer equipment used shall be of such design and construction as will permit the accurate control of the amount of water to be added. The amount of water used in the base mix shall be sufficient to obtain the required density at the time of compaction. The net amount of water to be added at the mixer shall be adjusted for moisture contained in the material, for the moisture they will absorb, and for any moisture loss between the time of mixing and compaction on the grade.

301-4.9 SPREADING AND COMPACTION. Each type of mixing equipment shall place the mixture on the grade or in the windrow in a loose condition. The material in a windrow shall be spread by a blade grader or a motor patrol to the required depth or contour. Immediately upon completion of the spreading operation, the base mixture shall be thoroughly compacted with sheepfoot rollers. Compaction shall begin at the bottom and shall continue until the entire depth and width of the base is uniformly compacted to the density specified. The tamping roller shall be removed when about one (1)

inch of loose material remains on the surface. The rate of operation and the number of rollers shall be sufficient to compact uniformly the section for the width and depth of base being processed within two (2) hours.

After the mixture, excepting the top one (1) inch, is compacted, the surface of the base shall be reshaped to the required lines, grades, and cross section and then lightly scarified to remove any imprints left by the compacting and shaping equipment. The resulting surface shall be thoroughly rolled with powered rollers and pneumatic rollers. The rolling shall be supplemented with the use of nail drags and broom drags. When directed the surface finishing methods may be varied but the procedure shall provide a dense, uniform, surface free from compaction planes. The moisture content of the surface material shall be maintained at its specified optimum during the finishing operations. Surface compaction and finishing shall be done in such a manner as to produce, in not over two (2) hours, a smooth, closely knit surface, free from cracks, ridges, or loose material, conforming to the crown, grade, and lines shown on the plans.

The required moisture content shall be determined by making laboratory density test in accordance with A. A. S. H. O. Method T-99. The base course shall be compacted to the best density obtainable, but not less than 95 percent as determined by the CAA compaction control tests T-611 for the class of airport involved.

301-4.10 CONSTRUCTION JOINTS. At the end of each day's run a transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true transverse vertical face.

The protection provided for construction joints shall be such as to permit the placing, spreading, and compacting of base material without injury to the work previously laid. Where it is necessary to operate or turn any equipment on completed base course, sufficient protection and cover shall be provided to prevent injury to work previously laid. A supply of mats or wooden planks shall be maintained and used as approved and directed by the engineer.

Care shall be exercised to insure thorough compaction of the base material immediately adjacent to all construction joints. When spreading or compacting base material adjacent to a previously constructed lane, ample care shall be taken to prevent injury to the work already constructed.

301-4.11 PROTECTION AND COVER. After the base course has been finished as specified herein, it shall be protected against rapid drying for a period of seven (7) days by applying not less than four (4) pounds of straw or hay per square yard or other materials approved by the engineer. The curing materials shall be moistened initially and subsequently as may be necessary. Waterproof paper blankets, burlap, or cotton mats may be used for protection of the base and shall be of a type and quality approved by the engineer.

The protective cover shall be removed immediately after this seven

(7) day period. Prior to the application of the prime, sufficient time shall be allowed for the surface to partially dry. The surface shall be carefully broomed and cleaned of all loose material in preparation for the application of the bituminous prime. This prime shall consist of either emulsified asphalt or tar, whichever is called for in the bid schedule.

301-4.12 CONSTRUCTION LIMITATIONS. Cement shall be applied only to such an area that all the operations specified in paragraphs 4.7 to 4.9, inclusive, can be continuous, and all but final surface finish completed within six (6) hours after the beginning of water application to the thoroughly mixed soil cement. No cement shall be applied when the percentage of moisture in the soil in the layer immediately beneath the pulverized material exceeds the optimum moisture content specified by the engineer for that particular soil, or when the percentage of moisture in the pulverized soil exceeds the optimum moisture of the soil cement mixture by more than two (2) percent. When any of the operations after the application of cement are interrupted for more than thirty (30) minutes for any reason, or when the uncompacted soil cement mixture is wetted by rain so that the average moisture content exceeds the tolerance given, the entire section shall be reconstructed in accordance with this specification. In the event the uncompacted soil cement mixture is wetted by rain so that the moisture content exceeds the tolerance above specified, then the contractor will be paid for the additional cement which is used in reconstructing the section. All material along longitudinal or transverse construction joints not properly compacted shall be removed and replaced with properly moistened and mixed soil cement which will be compacted to specified density.

301-4.13 SURFACE TESTS. The finished surface shall not vary more than three-eighths ($\frac{3}{8}$) inch when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the center line. Any variations in excess of this tolerance shall be repaired by the contractor, at his own expense, and in a manner satisfactory to the engineer.

301-4.14 THICKNESS. The thickness of the soil cement base course shall be determined from measurements of cores drilled from the finished base or from thickness measurement at holes drilled in the base for each day's work at intervals of five hundred (500) feet or less, and at locations selected by the engineer. The average thickness of the base constructed during one (1) day shall be within one-half ($\frac{1}{2}$) inch thickness shown on the plans, except that the thickness of any one point may be within three-fourths ($\frac{3}{4}$) of an inch of that shown on the plans. Where the average thickness shown by the measurements made in one (1) day's construction is not within the tolerances given, the contractor will be required to reconstruct this day's work at his own expense.

301-4.15 MAINTENANCE. The contractor shall be required to maintain, at his own expense, the entire base course within the

limits of his contract in good condition, satisfactory to the engineer, from the time he first starts work until all the work shall have been completed. Maintenance shall include immediate repairs of any defects that may occur either before or after the cement is applied, which work shall be done by the contractor at his own expense and repeated as often as may be necessary to keep the area continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface and durability of the part repaired. Faulty work must be replaced for the full depth of treatment. Any low areas will be remedied by replacing the material for the full depth of treatment rather than adding a thin layer of soil cement to the completed work.

METHOD OF MEASUREMENT

301-5.1 The yardage of soil cement base course to be paid for shall be the number of square yards of completed and accepted base course.

301-5.2 The amount of Portland cement to be paid for shall be the number of barrels of cement actually used as authorized.

BASIS OF PAYMENT

301-6.1 The yardage of soil cement base course, as provided above, shall be paid for at the contract unit price bid per square yard in the bid schedule for soil cement base course, which price and payment shall constitute full compensation for furnishing all materials except Portland cement; for loading, hauling, and placing; for pulverizing the soil; for handling, hauling, and spreading the cement; for mixing, blading, sprinkling, shaping, and compaction; for finishing, curing, and maintenance; for reconditioning of the underlying course and shoulders; for reconstruction of irregular surface, deficient thickness, and unsatisfactory base; for refilling test holes; for all pit or quarry moves; for clearing, stripping, drainage, and clean-up of pits; and for all labor, equipment, tools, water, and incidentals necessary to complete the work.

301-6.2 Portland cement shall be paid for at the contract unit price bid per barrel in the bid schedule for Portland cement, which price and payment shall constitute full compensation for delivery on the project and incorporated in the completed and accepted base course.

The removal of unsatisfactory soil and the addition of satisfactory borrow material will be paid for at the contract price for unclassified excavation or common excavation.

Prime coat will be paid for under a separate item.

Payment will be made under:

Item P-301-6.1 Soil Cement Base Course—per square yard.

Item P-301-6.2 Portland Cement—per barrel.

ITEM P-302 LEAN MIX ROLLED CONCRETE BASE COURSE

DESCRIPTION

302-1.1 This item shall consist of the construction of a lean mix, cement aggregate base course, consisting of Portland cement, selected granular materials and water, proportioned and mixed in a central plant, spread on the prepared underlying course and compacted in such manner as to achieve the maximum practicable density, and cured, all as hereinafter specified. The base shall be placed in one course in conformity with the dimensions and typical cross section shown on the plans and with lines and grades established by the engineer.

MATERIALS

302-2.1 CEMENT. Portland cement shall conform to the requirements of the standard specification of A. S. T. M. Designation C-150. Cement which has been stored other than in the bins at the mills, for more than four (4) months after being tested, shall be re-tested before use. Ordinarily, no cement shall be used until after it has satisfactorily passed all the 7- and 28-day standard test requirements, but in cases of emergency the engineer may waive the 28-day tests and permit the use of cement which has satisfactorily passed the soundness and 7-day tensile strength tests; provided, it is the product of a quarry and mill having established a reputation of not less than three (3) years standing, for the production of high grade cement.

Immediately upon receipt at the site of the work, cement, unless used directly from the carrier, shall be stored in a thoroughly dry, weather-tight, and properly ventilated building with adequate provisions for the prevention of the absorption of moisture. Storage shall be such as to permit easy access for inspection and definite identification of each shipment. Cement that for any reason has become damaged or partially set shall be rejected.

When specified or permitted by the engineer, high early strength cement conforming to the requirements of A. S. T. M. Designation C-150, Type III, shall be used. If high early strength cement is used, the operating time requirements shall be changed as directed by the engineer.

302-2.2 WATER. The water used in mixing shall be clean, clear, and free from injurious amounts of sewage, oil, acid, strong alkalis, and other foreign or deleterious matter. If the water is of

questionable quality it shall be tested in accordance with A. A. S. H. O. Method T-26. Water shall be supplied by the contractor in sufficient quantities to comply with the requirements of these specifications.

302-2.3 AGGREGATES. The aggregates shall be obtained from the sources or pits designated on the plans or as approved by the engineer. The combined aggregate shall consist of material having not more than seventy (70) percent or less than forty-five (45) percent passing a No. 4 mesh sieve.

The aggregate shall be separated into two sizes and stored in separate stock piles or storage bins unless otherwise permitted by the engineer. The separation shall be made on a $\frac{3}{8}$ -inch sieve or a $\frac{5}{8}$ -inch sieve or a sieve size between these two. These sizes of aggregate shall be combined in the proper proportions as provided herein and as directed by the engineer at the time of mixing.

The total aggregate as it occurs in the pit or as combined for use shall, when tested on a No. 4 mesh sieve, conform to the following requirements.

(a) *Fine Aggregate.* The fine aggregate shall consist of sand having durable particles and free from injurious amounts of organic impurities. Sands showing a color darker than standard in the Standard Colorimetric Test of the A. S. T. M. Designation C-40 shall not be used unless it can be shown by strength tests that the darker color is caused by harmless materials.

The fine aggregate, when tested by means of laboratory sieves, shall conform to the following gradation:

Sieve designation	Percent by weight passing square mesh sieves
No. 4.....	80-100
No. 16.....	45- 80
No. 50.....	10- 40
No. 100.....	5- 25
No. 200.....	0- 10

(b) *Coarse Aggregate.* The coarse aggregate may be that part of the material coarser than a No. 4 mesh sieve from the same source as the fine aggregate, or may be material from another source. It may consist of a mixture or wholly of either crushed or uncrushed material. Oversize material shall be removed but may be crushed to the specified size and used. The coarse aggregate shall consist of durable particles free from adherent coatings and injurious amounts of shale, clay lumps, and soft fragments. The coarse aggregate shall have a percent of wear of not more than 50 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

When tested by means of laboratory square mesh sieves, it shall conform to the following limits of gradation:

<i>Sieve designation</i>	<i>Percent by weight passing square mesh sieves</i>
2-inch.....	100
1½-inch.....	95-100
¾-inch.....	40-100
No. 4.....	0- 5

The aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subjected to five cycles of the sodium sulphate soundness test using A. A. S. H. O. Method T-104.

CONSTRUCTION METHODS

302-3.1 OPERATION AT AGGREGATE PITS. All work involved in clearing and stripping pits and the handling of unsuitable material encountered shall be performed by the contractor. The contractor shall notify the engineer sufficiently in advance of the opening of any designated pit to permit staking of boundaries at the site, and to take elevations and measurements of the ground surface before any material is produced; also to permit the engineer to take samples of the material for tests to determine its quality and gradation, and to prepare a preliminary design of base mixture.

In order to prevent fluctuations in the gradation of the aggregates, the equipment used and the methods employed shall provide for taking material from a face or slope, extending the full depth of the designated excavation, and in such a manner as to provide a uniform supply of coarse and fine aggregates.

302-3.2 PROPORTIONING. It is the purpose of these specifications to so combine cement, aggregates, and water as to produce a base mixture which can be satisfactorily spread, compacted, and shaped as herein specified and have the desired strength and durability.

The amount of water required for satisfactory compaction and the amount of Portland cement per cubic yard of compacted mixture to obtain the desired strength and durability shall be determined by the engineer by preliminary tests for the particular aggregates available. The amount of water used in the base mix shall be sufficient to obtain the required density (see paragraph 3.6) at the time of compaction. This amount of water shall be just short of the amount which produces a jelly-like condition of the mix or a rubbery condition of the base under the roller. Wet mixes which become rubbery under the roller cannot be satisfactorily compacted. Dry mixes will produce low density and poor durability. The net amount of water to be added at the mixer shall be adjusted for the moisture contained in the aggregate, for the moisture they will absorb, and for any moisture loss between the time of mixing and compaction on the grade. The cement

content shall not in any case be less than three (3) sacks per cubic yard of compacted material.

The engineer shall determine and have available the approximate proportions of cement, aggregate, and water to be used for the proposed aggregate supply. Attention is called here to the basis of payment, paragraph 5.2, which provides that the cement will be paid for separately at the contract price per barrel.

Unless authority is granted by the engineer for the use of combined aggregates, the aggregates shall be separated into two sizes and stored in separated stock piles or bins. One bin or stock pile shall contain coarse material and one shall contain fine material.

The proportions of fine and coarse aggregates used in the combined mix shall be determined by the engineer and will be based on the most efficient and economical utilization of the local materials available. The mix design selected for the project shall produce an average compressive strength of not less than 1,500 pounds per square inch at twenty-eight (28) days for standard test specimens. The compressive strength shall be the average of not less than three six- (6) inch by five- (5) inch laboratory specimens converted to the equivalent strength of standard test specimens; i. e., specimens having a height twice the diameter (see A. S. T. M. Designation C-42).

Aggregates and cement shall be proportioned by weight except that when continuous mixers are used the proportioning may be by volume, provided the equipment regulating the rate of feed of the various materials is adjustable and is automatically controlled to furnish a uniform rate of flow of each material corresponding to the required proportions by weight. Water may be proportioned by weight or volume. One sack of cement will be considered as weighing ninety-four (94) pounds and one gallon of water as eight and thirty-three hundredths (8.33) pounds.

302-3.3 MIXING. The aggregates, cement, and water shall be mixed at a central mixing plant by means of a mixer having revolving spiral blades, or pug mill mixer, using either a batch or a continuous mixing process. Other types of mixers may be used provided their performance has been satisfactory and on condition that they have been approved by the engineer. Sufficient mixing capacity shall be provided to permit continuous construction of the individual base strips at the rate of not less than 125 tons per hour.

The mixing shall be continued until the cement and the water are evenly distributed through the mass, and a uniform mixture is obtained. In no case shall the period of mixing be less than forty-five (45) seconds from the time all materials are in the mixer.

Water shall be incorporated in the mix in the amount directed by the engineer and under such conditions as will permit accurate control of the amount of water added.

Attention is called to the necessity of a comparatively dry mix to permit placing and compacting as herein specified. The mixer equipment used shall be of such design and construction as will permit the

satisfactory handling (charging and discharging) and insure thorough mixing of such material.

Weighing and measuring equipment shall be of approved types capable of controlling the quantity of materials to within one (1) percent by weight of the amounts fixed by the engineer.

302-3.4 PREPARATION OF UNDERLYING COURSE.

All soft and yielding material and other portions of the underlying course which will not compact readily when rolled or tamped shall be removed, and any loose rocks or boulders found in the earth excavation shall be removed or broken off to a depth of not less than six (6) inches below the surface of the underlying course. All holes or depressions made by the removal of any unsuitable material shall be filled with an approved material and the course brought to line and grade and compacted. The entire course shall be rolled with a self-propelled three-wheel ten-ton roller, and no material shall be deposited thereon until the underlying course has been checked and approved.

After the underlying course has been prepared as specified above and immediately before the base material is placed, the course shall be tested as to crown and elevation by means of a level and rod or by an approved type of templet or planer which rides on the side forms. If additional material is used to bring the course up to the correct-elevation, it shall be moistened and tamped or rolled until the filled material is entirely compacted and is as firm and unyielding as the surrounding surface. Any portion of the course which is not accessible for compaction by a roller shall be tamped thoroughly with hand tampers. If ordered by the engineer, water shall be applied to the course prior to and/or during rolling operations.

All hauling on the underlying course shall be kept to a minimum and shall be distributed over the width of the course. Any ruts and deformations shall be corrected and compacted prior to placement of the base material.

302-3.5 FORMS. When forms are required they may be of wood or of metal and shall be placed to line and grade as staked by the engineer. Wood forms shall have a thickness of not less than that of a commercial four (4) inch timber, shall have a height equal to the compacted depth of the base, and shall be not less than twelve (12) feet in length. All form lumber shall be of good quality timber, straight, well-seasoned, clean, and free from defects which would impair its usefulness. Forms becoming warped, split, worn, or otherwise defective shall be discarded.

Steel forms shall be of a section commonly required for Portland cement concrete pavement. They shall be of a depth at least equal to the edge thickness of the work prescribed. They shall be straight and free from warp. The minimum length of section of steel form shall be ten (10) feet.

All forms shall have full bearing on the compacted underlying course and shall be braced and staked in such manner as may be required to hold them rigidly in vertical position and true to established line and

grade while the concrete base material is being placed and consolidated. Forms shall be placed to accommodate the spreading equipment used, and shall extend at least five hundred (500) feet in advance of the placing operations. The forms shall be cleaned and oiled before each use. Forms shall be removed in such a manner as to avoid injury to the edge of the base.

When directed by the engineer, side forms will not be required. In such cases the spreading equipment and supply of base mixture shall be such as will permit the continuous and satisfactory spreading and compacting of material to the proper thickness and contour as described under paragraph 3.6, "Placing," for one- or two-lane construction.

302-3.6 PLACING. The prepared underlying course shall be free of all ruts or soft, yielding places. The surface, if dry, shall be moistened but not to the extent of producing a muddy condition at the time the base mixture is placed.

The mixed base material shall be transported in suitable trucks provided with protective covers, and shall be spread on the prepared underlying course in a manner to produce a layer of loose mixture of uniform density to such depth that, when thoroughly compacted, it will conform to the grade and dimensions shown on the plans. Not more than thirty (30) minutes shall elapse between the time the base material is mixed and the time it is deposited in place in the base course.

The materials shall be spread by a spreader box, self-propelled spreading machine, or other method approved by the engineer. The lean mix concrete shall not be placed in piles or windrows. If spreader boxes or other spreading machines are used that do not spread the material the full width of the lane or width being placed in one construction operation, a sufficient number shall be provided and operated in staggered formation so as to obtain full width spreading. If, in the opinion of the engineer, full width construction is found to be undesirable because of inadequate equipment, operating difficulties or climatic conditions, the base shall be constructed in partial widths. If the time elapsing between the placing of adjacent partial widths exceeds one-half hour, a vertical construction joint satisfactory to the engineer shall be provided.

The spreading equipment and methods employed in spreading the base material shall be such as will insure satisfactory accuracy and uniformity as to depth and width. Track marks produced by any power equipment attached to the spreader, which rides on freshly spread material behind the strike-off templet, will not be considered objectionable provided no displacement of materials occurs which subsequent compaction cannot remove. Spreading equipment shall not exceed twenty-five (25) feet or be less than nine (9) feet in width. If conditions arise where such uniformity in the spreading cannot be obtained, the engineer may require such additional equipment or modification in the spreading procedure as may be necessary to obtain satisfactory results.

Immediately upon completion of the spreading operations the base material shall be thoroughly compacted. Self-propelled rollers, of either three-wheel or three-axle four-wheel type, weighing not less than ten (10) tons shall be used; vibratory equipment, or other equipment which will produce to the satisfaction of the engineer the required degree of compaction throughout the full depth and width of the base may be used in lieu of rollers. Care shall be exercised in routing construction equipment in order to avoid the formation of unnecessary ridges due to wheel tracks or tractor treads. If necessary the base material, after compaction, shall be trimmed by means of self-propelled motor grader to the grade and section shown on the plans. All material loosened in this operation shall be swept from the surface before any further rolling. Finishing operations shall be continued until the surface is true to the specified cross section and will not show a variation of more than three-eighths ($\frac{3}{8}$) inch from a sixteen (16) foot straightedge laid in any location parallel to the longitudinal axis of the pavement.

It is the intent of this specification to secure the practical maximum weight of dry materials per cubic foot of compacted base material. In no case shall the weight of dry materials per cubic foot be less than ninety-six (96) percent of the weight per cubic foot, determined by the engineer, as agreeing with the standard density obtainable with the equipment and materials used. The density shall be determined by methods described in the CAA compaction control tests T-611 for the class of airport involved. The base material shall be compacted immediately after spreading, and not more than forty-five (45) minutes shall elapse between the time of spreading and the completion of the final rolling to obtain maximum density as given above.

No equipment or traffic which, in the opinion of the engineer, will damage the base course or the curing material shall be permitted on the finished base course during the seventy-two (72) hour curing period.

302-3.7 CONSTRUCTION JOINTS. At the end of each day's run a transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true transverse vertical face. These faces shall be protected by banking damp earth against them or by other approved suitable methods.

The protection provided for construction joints shall be such as to permit the placing, spreading, and compacting of base material without injury to the work previously laid.

When a longitudinal construction joint is required in part width construction, side forms shall be used or it shall be formed by cutting back into the compacted material to form a true vertical edge. Suitable curing shall be provided for any exposed longitudinal edge.

Care shall be exercised to insure thorough compaction of the base material immediately adjacent to all construction joints.

302-3.8 CURING. Curing material shall be applied to each portion of the finished base within one (1) hour after such portion has

been compacted and finished. The curing of the base and exposed edges shall be carefully and systematically accomplished in accordance with the following provisions:

As soon as possible after the surface has been finished, it shall be covered with any one of the curing materials hereinafter specified. Where, in the opinion of the engineer, too long a period of time elapses between finishing the base and applying the curing material, and attendant weather conditions cause detrimental drying of the surface, sprinkling of the base may be required before application of the curing material. In sprinkling, care shall be taken that the surface of the base is not damaged. The following materials and methods may be used for curing:

Bituminous Seal Coats. The bituminous coats shall consist of a homogeneous emulsion made from petroleum asphalt, or of an asphalt cut-back, and complying with the requirements for rapid curing products RC-1 or RC-2. The asphalt emulsion shall meet the requirements of the standard specifications, A. S. T. M. Designation D-401. The asphalt cut-back shall meet the requirements of A. A. S. H. O. Specification M-81.

The grade of the asphalt and the quantity applied shall be determined by the engineer but the quantity shall be approximately two-tenths (0.2) gallon per square yard.

Impermeable Paper. The surface of the base shall be wetted and covered with blankets of impermeable paper. The paper for curing shall meet the requirements of the standard specifications, A. S. T. M. Designation C-171. These blankets shall remain in place for a period of not less than seventy-two (72) hours. The blankets shall be lapped at least eighteen (18) inches and these laps shall be weighted with a windrow of earth or by other approved methods to form a closed joint. At the edge of the base the blankets shall be weighted securely with a continuous windrow of earth to provide contact. Blankets may be reused provided they are free from perforations and tears and are kept serviceable with repairs. Any blankets which, in the opinion of the engineer, does not comply with this requirement shall be discarded.

Wetted Straw. The surface of the base shall be covered with clean, loose straw applied at the rate of not less than four (4) pounds per square yard. Straw covering should be saturated with water as soon as placed, and kept saturated for a period of not less than seventy-two (72) hours from the time applied. Care shall be taken to see that the edges of the base are protected with straw or earth. The straw may be reused when, in the opinion of the engineer, it is in satisfactory condition. Upon completion of the curing period the straw shall be removed and disposed of as directed by the engineer.

Wetted Mats. Blankets made from at least two layers of burlap or from mats of cotton sandwiched between burlap, cotton fabric, or other similar material, shall be presaturated with water, applied to the base, and kept saturated for a period of not less than seventy-two

(72) hours. The mats shall be placed so that the entire surface and edges of the slab are completely covered.

302-3.9 COLD WEATHER PROTECTION. The base material shall not be mixed or placed when the temperature is below freezing except under such conditions as the engineer may direct. If at any time during the progress of the work the temperature is or will, in the opinion of the engineer, within twenty-four (24) hours, drop to thirty-five (35) degrees Fahrenheit the water and/or the aggregates shall be heated and precautions should be taken to protect the base from freezing. During cold weather when the air temperature may be expected to drop below thirty-five (35) degrees Fahrenheit a sufficient supply of hay, straw, or other material suitable for covering and protection shall be provided at the site of the work. Any base which has been damaged by freezing, or otherwise, shall be removed and replaced by the contractor at his own expense.

METHODS OF MEASUREMENT

302-4.1 The quantity of one course, lean-mix concrete base, to be paid for will be determined by measurement of the number of square yards of base actually constructed and accepted by the engineer as complying with the plans and specifications.

302-4.2 The quantity of Portland cement to be paid for will be the number of barrels of cement actually used in the base as authorized by the engineer. One barrel of Portland cement shall be considered to weigh three hundred seventy-six (376) pounds.

BASIS OF PAYMENT

302-5.1 The quantity of lean-mix concrete base, as determined, shall be paid for at the contract unit price per square yard of base in place, which contract price and payment shall be compensation in full for furnishing all materials, except Portland cement, for transporting, handling, preparing, mixing, and placing the materials; for rolling and finishing; for curing and curing materials; for clearing, stripping, and cleaning up aggregate pits; for handling and disposing of unsuitable material; for such clean-up operations as are necessary to leave the site of the work in an orderly and acceptable condition; and for all labor, equipment, tools, and incidentals necessary to complete the item.

302-5.2 Portland cement shall be paid for at the contract unit price bid per barrel in the bid schedule for Portland cement, which price and payment shall constitute full compensation for delivery on the project and incorporation in the completed and accepted base course.

Payment will be made under:

Item P-302-5.1 Lean-Mix Rolled Concrete Base Course—per square yard.

Item P-302-5.2 Portland Cement—per barrel.

FLEXIBLE SURFACE COURSES

ITEM P-401 BITUMINOUS SURFACE COURSE (Central Plant Hot Mix)

DESCRIPTION

401-1.1 This item shall consist of a surface course composed of mineral aggregate and bituminous material, mixed in a central mixing plant and placed on a prepared course, in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer.

When called for or shown on the plans, the surface course shall be constructed in two or more courses. Each shall be constructed to the depth, typical section, or elevation required by the plans. The leveling, binder, or base course shall be rolled, finished, and approved before the placement of the surface course, in the manner specified.

401-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight, to be added to the aggregate shall be fixed by the engineer on the basis of preliminary laboratory tests and field sieve analysis on the aggregate furnished, and shall be within the range as shown in the table.

401-1.3 JOB MIX FORMULA. No work shall be started on the project, nor any mixture accepted therefor, until the contractor has submitted samples of the materials intended for use and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate, and for bituminous cement; also the intended temperature of completed mixture at the time it is discharged from the mixer. The material furnished shall conform to the approved job mix formula within the tolerances specified herein:

JOB MIX TOLERANCES

	<i>Plus or Minus</i>
Aggregate passing sieve No. 4 and larger-----	5 percent.
Aggregate passing Nos. 10, 40, and 80 sieves-----	4 percent.
Aggregate passing No. 200 sieve-----	2 percent.
Asphaltic cement-----	0.4 percent.
Temperature of mixing and placing-----	25° F.

MATERIALS

401-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, crushed slag, screenings, gravel, sand-gravel, sand, or other natural, granular, approved material having essentially the same qualities and meeting all the requirements when combined within the limits for gradation.

For the surface course at least forty (40) percent by weight of the mineral aggregate, including filler, shall have been produced by the crushing of stone, slag, or gravel. When produced from gravel, only those particles having one or more fractured faces shall be considered as crushed.

Aggregate containing forty (40) percent to one hundred (100) percent crushed material will be required in surfaces to withstand parking and locked-wheel turns on special sections. These sections are ends of runways, plane-parking areas, apron areas, or such sections subjected to similar wear and loads. The percent of crushed aggregate required will be indicated in the proposal.

The aggregate shall be tough, durable, and sound. The aggregate shall consist of angular fragments reasonably uniform in density and quality and shall not contain more than eight (8) percent of either thin, elongated, and soft pieces, or dirt, or other objectionable matter. The coarse aggregate when tested in accordance with the Los Angeles Rattler Test, after five hundred revolutions, shall have a percent of wear of not more than forty-five (45) according to the A. A. S. H. O. Method T-96. The coarse aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subjected to five cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

Slag shall be air cooled, blast furnace slag, and shall have a compact weight of not less than seventy (70) pounds per cubic foot.

The portion of the material retained on a No. 4 mesh sieve shall be known as coarse aggregate; that portion passing a No. 4 mesh sieve shall be known as fine aggregate, and the material passing the No. 200 mesh sieve shall be known as filler. The composite material shall meet the requirements for one of the gradations given in Tables 1 or 2, using A. A. S. H. O. Methods T-11 and T-27.

That portion of the fine aggregate, including any blended filler, passing a No. 40 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91, and a liquid limit of not more than 25 as determined by A. A. S. H. O. T-89.

The composite aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The bituminized aggregate shall have a swell of not more than one and one-half ($1\frac{1}{2}$) percent as determined by A. A. S. H. O. Method T-101.

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be

determined. This shall be done by preparing a test sample of the paving mixture in conformity with the specifications contained herewith. After the mixture has been made it shall be spread out in a loose thin layer and allowed to air-season for twenty-four (24) hours before testing. A suitable size sample (approximately one-half ($\frac{1}{2}$) contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap. The sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing-off of the bituminous coating occurs, it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state or the aggregate shall be rejected.

401-2.2 FILLER. If filler, in addition to that naturally present in the aggregate, is necessary it shall consist of stone dust, loess, Portland cement, or other approved mineral matter. Stone dust shall be specified and used with sand-asphalt surface courses. The filler material shall meet the requirements of A. A. S. H. O. Specification M-17.

401-2.3 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregate at the central plant shall conform to the grade, requirements, and specifications as follows:

The asphalt cement for hot central-plant mix shall meet the requirements of A. A. S. H. O. Specification M-20 or M-22. The penetration of petroleum asphalt shall be between 100 and 150. The penetration of native asphalt cement shall be between 85 and 150. A limited range or grade shall be selected for each project, such as 85-100, 100-120, or 120-150. The penetration grade shall be indicated in the proposal, shown on the plans, or as directed by the engineer. Petroleum asphalt cement shall not be cracked.

NOTE: When native asphalt cement contains mineral filler, the penetration grade selected will depend upon the amount of inorganic filler present.

401-2.4 HYDRATED LIME. The hydrated lime shall meet the requirements of the A. S. T. M. Designation C-6.

COMPOSITION

401-3.1 COMPOSITION OF MIXTURE. The mineral aggregate for the surface course shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to one of the following gradations. The percent by weight for the bituminous material shall be within the limits given.

TABLE 1.—*Aggregate-Asphalt Surface Course*

Sieve size	Percentage passing sieves (square openings)		
	A 1" maximum	B ¾" maximum	C ½" maximum ¹
1-inch.....	100	-----	-----
¾-inch.....	82-100	100	-----
½-inch.....	70- 90	82-100	100
¾-inch.....	60- 82	68- 90	82-100
No. 4.....	42- 70	50- 79	56- 88
No. 10.....	30- 60	36- 67	40- 75
No. 40.....	15- 40	17- 44	19- 48
No. 80.....	8- 26	9- 29	10- 32
No. 200.....	3- 8	3- 8	4- 9
Asphalt cement, percent:			
Stone or gravel.....	4.5-7.0	5.0-7.5	5.5- 8.0
Slag.....	6.0-9.0	6.5-9.5	7.0-10.0

¹ The ½-inch maximum gradation shall not be used in preparing mixtures for turnarounds and parking areas.

TABLE 2.—*Sand-Asphalt Surface Course*

[This table will not be considered unless its use is permitted in the proposal]

Sieve size	Percentage passing sieves (square openings)
	D ¾" maximum
½-inch.....	100
¾-inch.....	91-100
No. 4.....	75-100
No. 10.....	56- 85
No. 40.....	24- 56
No. 80.....	12- 37
No. 200.....	4- 10
Asphalt Cement, percent.....	6.0-8.5

In the table the percentages of asphalt cement are given for stone, gravel, and slag aggregates. If the total aggregate is composed of slag, the percentages of bituminous material shown shall be used. Where only a part of the aggregates is slag, the increase in bituminous material shall be made in a corresponding proportion.

The gradations in these tables represent the limits which shall determine suitability of aggregate for use from the sources of supply. The final gradations decided on within the limits designated in the table shall be uniformly graded from coarse to fine, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The selection of any of the gradations shown in the tables shall be such that the maximum-size aggregate used shall not be more than one-half ($\frac{1}{2}$) the thickness of the layer of the surface course being constructed.

A sample of the coarse and fine aggregates shall be washed to determine the percentage of the total material passing the No. 200 mesh sieve. Of the amount of the material passing the No. 200 mesh sieve, at least one-half ($\frac{1}{2}$) shall pass the No. 200 mesh sieve by dry sieving.

The composition limits tabulated shall govern, but a closer control appropriate to the job materials will be required for the specific project in accordance with a job-mix formula.

The weights for the measurement of the bituminous mixtures should be based on the bulk specific gravity of aggregates of 2.65. Proportionate corrections shall be made when the aggregates furnished on the job (job aggregate) have bulk specific gravities above 2.75 or below 2.55.

CONSTRUCTION METHODS

401-4.1 WEATHER AND SEASONAL LIMITATIONS.

The surface course shall be constructed only when the surface upon which it is to be placed is dry, when the atmospheric temperature is above 40° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

401-4.2 EQUIPMENT. (a) *General.* All methods employed in performing the work and all equipment, tools, and other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The paving plant used by the contractor in the preparation of the bituminous concrete shall comply with the following requirements:

The drier shall be suitably designed to heat and dry the aggregate to specification requirements and to continuously agitate the aggregate during heating. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant to meet the specification requirement. A dial thermometer or other approved thermometric instrument shall be so placed at the discharge chute of the drier as to automatically register or indicate the temperature of the heated aggregate.

All plant screens shall be designed, constructed, and operated so as to screen all aggregates to appropriate fractions as established by the engineer and as necessary to meet the job mix tolerances.

The plant shall have storage bins, protected from the weather, of sufficient capacity to furnish the necessary amounts of all aggregates when operating at the maximum rated capacity of the plant. The

bins shall provide three or more compartments for hot aggregates of $\frac{3}{4}$ -inch maximum size or larger gradations and two or more compartments for $\frac{1}{2}$ -inch maximum size aggregate or smaller, so proportioned as to insure adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe or other device which meets the approval of the engineer, of such size and at such location as to prevent backing up of material into other compartments. When required by the engineer, a dial thermometer or other approved thermometric instrument shall be so placed in the bin over the mixer as to automatically register or indicate the temperature of the heated aggregate immediately before it enters the mixer. The dial or other indicator shall be plainly visible from the mixing platform.

Adequate and dry storage for mineral filler shall be separately provided. Provisions shall be made for the weighing of filler by separate approved scales or by a separate beam on the weigh box scales.

The plant shall have a batch-weighing device for the dried mineral aggregates. This equipment shall be constructed for easy adjustment of any working part so that it will function properly and accurately. The weigh box or hopper shall be supported on fulcrums and knife edges so made that they will not be easily thrown out of alignment or adjustment. The hopper must be free from contact on all edges, ends, or sides with any supporting rods or columns or other equipment that will in any way affect its proper functioning. In addition there must be sufficient clearance between the hopper and supporting devices so that foreign materials will not accumulate. The discharge gate of the hopper shall be so hung that the aggregates will not be segregated when dumped in the mixer. If necessary to correct any such tendency, baffles shall be inserted or other means provided to discharge the materials in a blended condition. The plant shall have a capacity of at least forty (40) tons per hour.

Scales for the weigh box may be either of the beam or springless-dial type, and shall be a standard make and design, sensitive to one-half ($\frac{1}{2}$) of one (1) percent of the maximum load that may be required. When of the beam type, there shall be a separate beam for each size of aggregate and there shall be a "telltale" dial scale attached. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. Beam scales shall be balanced on knife edges and fulcrums and be so constructed that they cannot be easily thrown out of alignment and adjustment. Dial scales shall be of a standard make and of sufficient size that the numerals on the dial can be read at a distance of not less than twenty-five (25) feet. All dial scales shall be so located that they will be in plain view of the operator at all times.

Scales for the weighing of asphalt cement shall conform to the specifications for the aggregate scales except that beam scales shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not be greater than two (2) pounds. Dial scales for weighing the asphalt cement shall have a

capacity of more than twice the weight of the material to be weighed, and shall read to the nearest pound.

The contractor shall provide, and have at hand, the necessary number of standard test weights for frequent testing of all scales.

The asphalt weigh bucket shall be steam-jacketed or be insulated with other temperature controls. It shall be supported on fulcrums and knife edges in the same manner as the weigh box, and have a capacity equal to twelve (12) percent by weight of the maximum capacity of the mixer.

The mixer shall be a standard twin pug-mill type of sufficient size to maintain thorough uniform mixing at the rated plant capacity. The mixer shall be equipped with a sufficient number of paddles or blades set in the proper order and position to produce a satisfactory mixture of any material required under these specifications. When the clearance is equal to or exceeds two (2) inches, either the shortened blades or the worn liners (or both) shall be replaced to reduce the clearance to two (2) inches or less. If sufficient mixing and coating is not secured at the minimum mixing time specified, the right is reserved to increase the required mixing time as may be judged necessary by the engineer. The mixer shall be steam-jacketed or properly insulated with other temperature controls. The capacity of the mixer shall be at least 1,200 pounds.

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

Equipment for heating bituminous material shall consist of kettles or tanks with steam coils or other suitable heating devices. Under no circumstances shall a direct flame come in contact with the heating kettles; steam coils shall be so designated that steam will not be introduced into the material. A recording thermometer shall be provided, which will record the temperature of the bituminous material at the draw-off valve.

Asphalt storage and supply lines shall be insulated or steam-jacketed in such a manner that there will be no appreciable drop in temperature of the asphalt between the heating unit and the mixing unit.

A volumetric proportioning, continuous mixing type of plant may be substituted for the above weigh-batch type when approved by the engineer and provided the equipment has demonstrated that it is suitable in producing the required gradation control of aggregates and uniformity of mixture. The number of bin compartments provided shall be the same as stipulated above for batch-type plant. The plant shall include a feeder mounted under the bin compartments and a means of accurately proportioning each bin size of aggregate by accurately controlled individual gate to form an orifice for measuring the material. The orifice shall be rectangular, of dimensions about eight (8) inches by nine (9) inches with one dimension adjustable by

positive mechanical means and provided with a lock. Indicators shall be provided on each gate to show the gate opening in inches. There shall be included a means for calibrating the gate openings by means of weight test samples. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins, and the flow of bitumen from the meter, or other proportioning source. This control shall be adjustable and, after being set, shall be capable of remaining fixed. The paddles of the continuous mixer shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge, and also giving the rate of feed of aggregate per minute at plant operating speed.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading, shaping, or finishing will be required to provide a surface which will comply with the requirements for thickness and smoothness contained herein.

(d) *Rolling Equipment.* Rollers shall be suitably designed for the construction of bituminous surfaces. The rolling shall be done with self-propelled tandem and three-wheel type rollers weighing not less than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking.

401-4.3 PREPARATION OF MINERAL AGGREGATE.

The aggregate for the mixture shall be dried and heated at the paving plant before entering the mixer. When introduced into the mixer the combined aggregate shall not contain more than one (1) percent moisture. Water in the aggregate shall be removed by heating to the extent that no subsequent foaming shall occur in the mixture prior to the placing of the material. The aggregate shall be heated to the temperature as designated by the job formula within the job tolerance specified. The maximum temperature and the rate of heating shall be such that no permanent damage occurs to the aggregates. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by heating. The aggregates shall be screened to specified sizes and conveyed into separate bins ready for mixing with bituminous material.

Additional filler, if necessary to meet the gradation requirements, shall be proportioned and added to the mineral aggregate. Filler may be added to the aggregate at the mixing plant by premixing it thoroughly with the other aggregates. Spreading filler over the tops of the aggregate pits or dumping it into the hoppers at crushing plants will not be permitted.

401-4.4 PREPARATION OF BITUMINOUS MIXTURE.

Before being delivered to the runway, the aggregate shall be mixed

with the bituminous material at a central mixing plant. The mixture shall be prepared at a temperature as directed by the engineer between 225° to 300° F.

Th dry aggregates, prepared as prescribed above, shall be combined in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer. In case of volumetric proportioning, the size of the gate openings shall be determined and the gates locked in position.

The bituminous material shall be melted in kettles or tanks designed to secure uniform heating of the entire contents. Asphalt shall not be heated over 325° F.

Kettles for storage of bituminous cement shall have a total capacity sufficient for one day's run and shall be capable of heating the bituminous cement with an effective and positive control of the heat at all times to a temperature of between 175° F. and 350° F. Heating of the cement by steam coils is preferred. The circulating system shall be constructed of adequate size to give the proper and continuous circulation of cement throughout the operating periods. All bituminous cement lines and fittings shall be insulated or steam jacketed.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the engineer, and shall be measured by weight and introduced into the mixer at the specified temperature, holding to the lowest range possible for adequate mixing and spreading. For batch mixers, all mineral aggregate shall be in the mixer before the bituminous material is added. The exact temperature to be used on the work within the specified range shall be fixed by the engineer. In no case shall aggregate be introduced into the mixture at a temperature more than 25° F. above the temperature of the bituminous material. The mixing shall continue for at least thirty (30) seconds and for such longer period as may be necessary to coat all of the particles.

From zero (0) to one (1) percent of Portland cement or hydrated lime shall be added to the composition of the surface mixtures when provided for in the proposal.

401-4.5 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be transported from the mixing plant to the point of use in pneumatic-tired vehicles having tight bodies previously cleaned of all foreign materials. When directed by the engineer, each load shall be covered with canvas or other suitable material of sufficient size and thickness to protect it from the weather or dust conditions.

The mixture shall be placed at a temperature between 200° F. and 300° F. When the mixture is being placed during warm weather, and the engineer has determined that satisfactory results can be obtained at lower temperatures, he may direct that the mixture be mixed and delivered at the lower temperatures.

No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during daylight unless arti-

ficial light, satisfactory to the engineer, is provided. The mixture shall be delivered at a temperature within the tolerance allowed in the approved job formula.

401-4.6 SPREADING AND LAYING. (a) *Preparation for placing.* Immediately before placing the bituminous mixture, the existing underlying course shall be cleaned of loose or deleterious material by sweeping with a power sweeping equipped with blower, supplemented by hand brooms if necessary, or as directed by the engineer.

The mixture shall be laid only upon an approved underlying course which is dry, which is in a suitable condition, and only when weather conditions are suitable. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 40° F. or under, unless so directed by the engineer. The engineer may, however, permit work of this character to continue when overtaken by sudden rains, up to the amount which may be in transit from the plant at the time, provided the mixture is within the temperature limits specified.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall commence at the point or points furthest from the mixing plant, and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed shall not be permitted until the material has been compacted thoroughly in the manner specified, and allowed to cool to atmospheric temperature.

Normally the surface course shall be laid in a compacted layer from one (1) inch to two (2) inches in depth. When the surface course is to be constructed in thickness greater than two (2) inches the course shall be placed in two or more layers.

(b) *Machine Spreading.* Upon arrival the mixture shall be dumped into an approved mechanical spreader and immediately spread thereby to the full width required. It shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate the pulling and tearing of the bituminous material.

Placing and compaction of the bituminous mixture shall progress in sections. The bituminous mixture shall be spread, shaped, and finished with the power machine specified. The mixture shall be placed in strips of a minimum width of ten (10) feet. To insure proper drainage, the spreading shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope. The six (6) inch strip adjacent to the area on which future material is to be laid shall not be rolled until such material has been placed, but shall not be left unrolled more than

two (2) hours after being placed. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted as provided for the first width, except that rolling shall be extended to include the six (6) inches of the first width not previously compacted. Whenever the adjacent or second width cannot be placed within two (2) hours, the six (6) inch strip shall not be left unrolled. After the second strip has been placed and rolled, a straightedge (minimum length of ten (10) feet) shall be used across the longitudinal joint to determine if the surface is to grade and contour.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If for any reason the spreading machine should drift away from an adjacent lane during construction, the unfilled space so made shall be carefully filled with fresh hot mixture obtained from the hopper of the spreading machine or from the truck. Stealing mixture from that already spread to fill up these areas shall not be permitted.

In limited areas where, on account of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impractical, the mixture may be spread by hand.

When hand spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread and be distributed into place immediately by means of hot shovels. It shall be spread with hot rakes in a uniformly loose layer to the full width required and of such depth that, where the work is completed, it will have the required thickness and will conform to the grade and surface contour shown on the plans.

Contact surfaces shall be painted with a thin uniform coat of hot asphalt cement, cut-back asphalt, or emulsion just before the mixture is placed.

401-4.7 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, the mixture shall be thoroughly and uniformly compacted by a power-driven three-wheel roller and tandem roller or rollers, weighing eight (8) tons or more. Rolling of the mixture shall begin as soon after spreading as it will bear the roller without undue displacement or hair checking. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the other edge.

Initial rolling shall be done longitudinally with tandem rollers and/or three-wheel rollers. The rollers shall overlap on successive trips. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling crossing the lines of the first after three or more lanes are constructed, but cross rolling shall not exceed more than one-half ($\frac{1}{2}$) width of the runway.

The speed of the roller shall at all times be slow enough to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause,

shall be corrected at once by the use of rakes, and of fresh mixture where required.

Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant. Rolling shall proceed at an average rate not to exceed 350 square yards per hour per roller. Rolling shall continue until all roller marks are eliminated, until the surface is of uniform texture and true to grade and cross section, and until the density of at least ninety-two (92) percent of the theoretical density is obtained. Field density tests shall be made at least twice daily. Final rolling shall be done with tandem rollers.

The theoretical density shall be computed as follows:

$$\text{Density} = \frac{100}{\frac{\% \text{ mineral aggregate by weight}}{\text{Sp. gr. mineral aggregate}} + \frac{\% \text{ bitumen by weight}}{\text{Sp. gr. of bitumen}}}$$

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated by competent and experienced rollermen. The rollers shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression and be free from objectionable roller marks.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to the application of the finish coat shall be removed and replaced with fresh hot mixture which shall be immediately compacted to conform with the surrounding area, all to be done at the expense of the contractor. Skin patching on an area that has been rolled shall not be allowed.

401-4.8 JOINTS. (a) *General.* The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the adjacent course for the full specified depth of the course. Joints shall be formed by cutting back on the previous day's run so as to expose the full depth of the course, and the exposed edge shall be given a light paint coat of asphalt, if necessary. The fresh mixture shall be raked against the joint, thoroughly tamped with tampers, and rolled.

(b) *Transverse.* The placing of the course shall be as nearly continuous as possible. The roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued.

(c) *Longitudinal.* The placing of the course shall be in the manner as specified and so that the joint is exposed for the shortest period possible. The joint shall be placed so that it will not coincide with that in the base or binder course, and will break joints by at least one (1) foot.

401-4.9 SHAPING EDGES. While the surface is being compacted and finished the contractor shall carefully trim the outside edges of the pavement to the proper alignment. The edge so formed shall be beveled while still hot with the back of a rake or a smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

401-4.10 SURFACE TESTS. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression, and any variation shall be corrected by removing or adding materials and continuing the rolling.

The finished surface shall not vary more than one-quarter ($\frac{1}{4}$) inch for the wearing course when tested with a sixteen (16) foot straight-edge applied parallel with or at right angles to the centerline.

After the completion of final rolling, the smoothness of the course shall again be tested; the humps or depressions exceeding the specified tolerances or that retain water on the surface shall be immediately corrected by removing the defective work and replacing with new material, as directed by the engineer, and at the expense of the contractor.

401-4.11 SAMPLING PAVEMENT. For the determination of composition, compaction, and density of the pavement the contractor shall remove suitable size samples of the completed pavement. Samples for each day or fraction thereof, when mixtures are placed, shall be taken by the engineer. The contractor shall replace the pavement where samples are removed, and these replacements shall be installed by the contractor free of charge. After the samples have been removed from the completed pavement, they will be tested by the engineer for density and composition. If the deficiency in composition and compaction exceeds the limits of toleration from that specified, satisfactory corrections shall be made.

401-4.12 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

For checking the adequacy of the equipment in use, inspecting the conditions and operation of the plant, for the verification of weights or proportions and character of materials and/or the determination and checking of temperatures being maintained in the preparation of the

mixtures, the engineer or his authorized representative shall have access at any time to all parts of the paving plant.

The contractor shall furnish vendor's certified test report for each carload or equivalent of bitumen shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

401-4.13 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

401-4.14 SEAL COAT. As shown on the plans and called for in the bid schedule, a seal coat of the type called for shall be applied to the finished course as described under SEAL COAT.

METHOD OF MEASUREMENT

401-5.1 The tonnage of surface course containing at least forty (40) percent crushed aggregate to be paid for shall be the number of tons of bituminous mixture of the gradation called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

401-5.2 The tonnage of surface course for use on turn-arounds, plane-parking areas, and other designated areas to be paid for shall be the number of tons of bituminous mixture of the gradation and composition called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

401-5.3 The quantities as measured in paragraphs 5.1 and 5.2 for surface mixtures are applicable for aggregates having a bulk specific gravity between 2.55 and 2.75, as determined by A. A. S. H. O. Methods T-84 and T-85. Proportionate corrections shall be made when the aggregate furnished on the job have bulk specific gravities above 2.75 or below 2.55. In the cases where the specific gravity is below 2.55 the correct quantity for payment shall be the product of the number of tons used multiplied by the ratio of 2.55 to the bulk specific gravity of the job aggregate. In the cases where the specific gravity is above 2.75 the correct quantity for payment shall be the

product of the number of tons used multiplied by the ratio of 2.75 to the bulk specific gravity of the job aggregate. The intent of the correction is to make the cost of the bituminous pavement approximately the same as when the tonnage is figured at the average specified gravity of 2.65.

401-5.4 The unit of measurement for the bituminous material shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F., in accordance with A. S. T. M. Designation D-206 for asphalt materials.

BASIS OF PAYMENT

401-6.1 The quantities of surfacing mixture and bituminous material determined as provided in 5.1, 5.2, 5.3, and 5.4 above shall be paid for at the respective contract unit prices per ton in the bid schedule for surface course and per gallon or per ton for bituminous material, which prices and payments shall constitute full compensation for preparing base or underlying course; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas; for reconditioning underlying course and shoulders; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; and for all labor, equipment, tools, and incidentals necessary to complete the item, except any seal coat.

Payment will be made under:

- Item P-401-6.1 Aggregate Bituminous Surface Course—per ton.
- Item P-401-6.1 Aggregate Bituminous Surface Course (Turn-arounds and Parking Areas)—per ton.
- Item P-401-6.1 Sand-Asphalt Surface Course—per ton.
- Item P-401-6.1 Bituminous Material—per gallon or per ton.

ITEM P-405 KEYSTONE MAT COURSE

DESCRIPTION

405-1.1 This item shall consist of a layer of keystone constructed on the prepared primed base in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer. The keystone shall consist of an application of bitumen covered with a layer of aggregate properly rolled and partially keyed to the base course. The keystone mat shall be protected with a double-surface treatment or surfaced with an asphaltic concrete-plant-mix wearing course, whichever is stipulated in the bid proposal.

405-1.2 QUANTITIES OF MATERIALS. The sequence of placing and the approximate amount of materials per square yard shall be as follows:

TABLE 1.—*Quantities of Materials*

Order	Bituminous material	Aggregate
	<i>Gals per sq. yd.</i>	<i>Lbs per sq. yd.</i>
1st application.....	0.30-0.40	
1st spreading.....		40-60

The weights given in Table 1 are those of aggregates having a bulk specific gravity of 2.65 as determined by A. A. S. H. O. Method T-85. Proportionate corrections shall be made when aggregates furnished on the job have bulk specific gravities above 2.75 or below 2.55.

The total amount of bituminous material and aggregate as given are approximate. The exact amount shall be determined by the engineer.

MATERIALS

405-2.1 AGGREGATE. The aggregate for the keystone shall be crushed stone, crushed or uncrushed gravel, or crushed slag, and shall meet the requirements for gradation as follows using A. A. S. H. O. Method T-27.

TABLE 2.—*Requirements for Gradation of Aggregate*

Sieve size	Percentage by weight passing square mesh sieves	
	No. 6	No. 7
1 inch.....	100	-----
¾-inch.....	90-100	100
½-inch.....	20- 55	90-100
⅜-inch.....	0- 15	40- 70
No. 4.....	0- 5	0- 15
No. 8.....	-----	0- 5

The aggregate shall consist of clean, tough, durable fragments free from flat, elongated, soft, or disintegrated pieces, dirt, or other objectionable matter, and shall have a percent of wear of not more than 45 at 500 revolutions as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

Crushed slag shall be air-cooled blast-furnace slag, reasonably uniform in density and quality, and shall weigh not less than sixty-five (65) pounds per cubic foot.

Aggregate shall be free from clay balls and adherent films of clay or rock dust, and shall be washed thoroughly if produced from moist material. Aggregate shall be of such nature that a thorough coating of the bituminous material to be used in the work applied to it will not slough off upon contact with water.

The aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subjected to five cycles of the sodium sulphate soundness test using A. A. S. H. O. Method T-104.

405-2.2 BITUMINOUS MATERIAL. The bituminous material to be furnished shall meet one of the following requirements:

The asphalt cement shall meet the requirements of A. A. S. H. O. Specification M-20. The penetration of the asphalt cement shall be between 150 and 225. The cement shall be applied at a temperature between 200° F. and 300° F.

The tar shall meet the requirements of A. A. S. H. O. Specification M-52. The grade shall be RT-10, RT-11, or RT-12. The grade will be indicated in the proposal or shown on the plans. The tar shall be applied at a temperature between 175° F. and 250° F.

The 90+ asphalt cement shall be homogeneous, free from water, shall not foam when heated to a temperature of 347° F., and shall meet the following requirements.

TABLE 3.—Requirements for the 90+ Asphalt Cement

Test requirements	A. A. S. H. O. test methods	Limits	
		Min.	Max.
Water, percent.....	T-55	-----	0
Furol vis. at 210° F.....	T-72	250	500
Flash point, ° F. (Cleve. Open Cup).....	T-48	275	-----
Distillations:			
Total distillate to 680° F., percent by vol.....	T-78	-----	2
Float test on residue at 122° F., sec.....	T-50	150	350
Asphalt residue of 100 pene., percent.....	T-56	90	-----
Duct. asphalt residue at 77° F., cm.....	T-51	100	-----
Percent sol. in CCl ₄ (Using CCl ₄ with T-44).....	-----	99.5	-----
Temperature of application, ° F.....	-----	200	275

The material shall not be cracked.

The emulsified asphalt shall be homogeneous and of such character that it will mix with distilled water in all proportions and shall meet the following requirements.

TABLE 4.—Requirements for Emulsified Asphalt

Test requirements	A. A. S. H. O. test methods	Grade		
		AE-200	AE-2	AE-3
Viscosity, Saybolt Furol, at 77° F. sec.....	T-59	20-120	100-400	At 122° F. 100-400
Residue at 325° F. percent.....	T-59	55-65	55-65	55-65
Demulsibility: 35 ml. of 0.02 N CaCl ₂ , not less than, percent.....	T-59	60	60	60
Sieve test, not more than, percent.....	T-59	0.05	0.05	0.05
Settlement 5 days, not more than, percent.....	T-59	5	3	3
Stone Coating Test.....	T-59	Shall pass	Shall pass	Shall pass
Temperature of application, ° F.....	-----	100-135	100-135	100-135
Sampling material.....	T-40	-----	-----	-----

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F., not less than.....	T-43	0.96	1.00	1.00
Penetration at 77° F., 100 g. 5 sec.....	T-49	150-225	150-225	150-275
Soluble in Carbon Tetrachloride, not less than, percent.....	T-45	97	97	97
Ductility at 77° F., not less than, cm.....	T-51	60	60	60
Ash, percent, not more than.....	-----	-----	2	2

The material shall not be cracked.

Coating test shall not show appreciable separation when emulsified asphalt is mixed with washed, dry, clean stone for three (3) minutes. The emulsified asphalt shall coat the stone thoroughly. The test for

cracked material shall be made on the asphalt prior to emulsification.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot and shall be kneaded until uniform and homogeneous. It shall then be tested for ductility.

CONSTRUCTION METHODS

405-3.1 WEATHER AND TEMPERATURE LIMITATIONS. Keystone mat course shall be constructed and operations shall be carried on only when the base is dry, when the atmospheric temperature is above 50° F., and when the weather is not foggy or rainy. The temperature requirements may be waived, but only when so directed by the engineer.

405-3.2 ORGANIZATION AND EQUIPMENT. Each unit required in the execution of these specifications shall be under the continuous supervision of a competent superintendent thoroughly experienced in this class of work. Experienced operators will be required on all equipment used in hauling and applying bituminous material and aggregates.

All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The following equipment will be the minimum required for this type of construction, and additional machinery must be secured if, in the opinion of the engineer, it is necessary to fulfill the conditions of these specifications or to complete the improvement within the time specified.

The distributor shall have pneumatic tires of such width and number that the load produced on the pavement surface shall not exceed 650 pounds per inch of tire width, and shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gages, volume measuring devices, and a thermometer for reading temperatures of tank contents. The distributor shall have a minimum capacity of 1,000 gallons.

The steel-wheel rollers shall be of the self-propelled tandem or three-wheel type rollers weighing not less than five (5) tons nor more than eight (8) tons. The wheels of the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surfaces. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing materials from sticking.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

The motor patrol grader shall be a modern unit, weighing not less than six (6) tons, with a blade not less than ten (10) feet, and equipped with a wire broom mould board.

The aggregate spreading equipment shall consist of a mechanical spreader box or tail-gate spreader attached to the rear of the hauling truck. The spreader shall be adjustable so as to spread accurately and evenly the required amounts per square yard. The spreader shall be supported on a wheel or wheels equipped with pneumatic tire or tires.

Equipment for heating bituminous material shall consist of a tank with steam coils so designed that steam will not be introduced into the material. Equivalent facilities that have been approved may be used.

The transfer supply tanks with a minimum of 1,000-gallon capacity shall be thoroughly insulated to retain heat. The number necessary shall depend on the length of haul from the source of supply and the rate of application of the bituminous material.

The number of steel-tired rollers furnished and operated on the project shall depend on the number of square yards of bituminous material distributed daily. A power roller shall be furnished for each ten thousand (10,000) square yards daily distribution of bituminous material.

405-3.3 CONDITIONING OF EXISTING UNDERLYING COURSE. The underlying course upon which the mat course is to be constructed shall have been conditioned and/or primed in accordance with CAA specification for prime coat.

405-3.4 APPLICATION OF BITUMINOUS MATERIAL. The bituminous material shall be applied uniformly to the course with the prescribed pressure distributor and in the amount per square yard determined by the engineer.

Bituminous material shall be so applied that uniform distribution is obtained at all points. Unless the distributor is so equipped as to obtain this result at the junction of applications, building paper shall be spread on the surface for a sufficient distance back from the end of each application so that flow through sprays may be started and stopped on the paper, and so that all sprays will operate properly on the entire length being treated. Building paper so used shall be immediately removed and burned. Application temperatures of bituminous material shall be as provided.

405-3.5 SPREADING AND ROLLING KEYSTONE. Keystone in the quantity specified shall be spread uniformly over the

bituminous material as soon after application as is possible. The aggregate shall be spread in the same width of application as for the bituminous material, and applied uniformly with the aggregate spreading equipment or by hand methods when authorized. Trucks spreading aggregate shall be operated backward so that bituminous material will be covered before truck wheels pass over it. The aggregate shall not be applied in such thickness to cause blanketing. Back-spotting or sprinkling of additional aggregate over areas that show up as having insufficient cover shall be done by hand spreading which shall be continued during the operations whenever necessary. The aggregate shall be suitably air dried and/or allowed to dry after spreading.

The initial rolling of the aggregate shall be done with a powered roller of the weight specified until keyed and set. The keystone shall be initially rolled within two (2) hours after spreading. Every effort should be made to prevent excessive rolling which would cause crushing of the aggregate. Following the rolling with the steel-tired roller, the keystone surface shall be further rolled with a rubber-tired multiple wheel roller to the satisfaction of the engineer to insure the proper embedding of the aggregate into the bitumen. Rolling shall progress parallel with the center line of the runway and lapping uniformly each preceding track by at least twelve (12) inches.

Along curbs, headers, and walls, and at all places not accessible to the roller, the aggregate shall be tamped thoroughly with mechanical tampers or with hand tampers. Each hand tamper shall weigh not less than fifty (50) pounds and have a face area of not more than one hundred (100) square inches.

Any aggregate in this or any subsequent spreading that becomes coated or mixed with dirt or clay prior to the application of the surface material shall be removed, replaced with clean aggregate, re-treated, and re-rolled at the contractor's expense.

405-3.6 MAINTENANCE. The proposal should provide for additional surfacing to be placed on this course. In case of delay in placing the additional surfacing, it shall be the contractor's responsibility to keep this course free from all foreign or objectionable material. All excess or loose aggregate shall be removed at the contractor's expense.

405-3.7 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

405-3.8 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and aggregate materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

405-4.1 The unit of measurement for the bituminous material for the keystone shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F., in accordance with A. S. T. M. Designation D-206, and in accordance with appropriate formulae or tables for emulsified asphalt or tar.

405-4.2 The tonnage of key aggregate to be paid for shall be the number of tons of key aggregate placed, rolled, and accepted in the work.

BASIS OF PAYMENT

405-5.1 The quantities of bituminous material and keystone aggregate, determined as provided in 4.1 and 4.2 above, shall be paid for at the respective contract unit prices per gallon in the bid schedule for bituminous material and per ton for key aggregate, which prices and payment shall constitute full compensation for furnishing, handling, manipulating, and placing all materials; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas; for furnishing and sealing of scales; for furnishing the weigh house; for all labor, equipment, tools, and incidentals necessary to complete the item, except any prime coat.

Payment will be made under:

Item P-405-5.1 Bituminous Material—per gallon or per ton.

Item P-405-5.1 Keystone Aggregate—per ton.

ITEM P-408 BLENDED NATURAL LIMESTONE AND SAND ASPHALT SURFACE COURSE

(Central Plant Hot Mix)

DESCRIPTION

408-1.1 This item shall consist of a wearing course composed of sand, natural limestone asphalt, and bituminous material, mixed in a central mixing plant and placed on the prepared base course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans and with lines and grades established by the engineer. The blended natural limestone and sand asphalt surface course mixture as specified shall be composed by weight of at least twenty (20) percent of natural limestone asphalt added to the sand.

408-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight, to be added to the aggregate and the native bituminous material in the limestone asphalt shall meet the requirements for bitumen as specified. The exact percentage to be used within the limits specified shall be fixed by the engineer on the basis of preliminary laboratory tests and field sieve analysis of the aggregate furnished.

408-1.3 JOB MIX FORMULA. No work shall be started on the project nor any mixture accepted therefor until the contractor has submitted samples of the materials intended for use and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for the sand, the limestone asphalt, and for asphaltic cement; also the intended temperature of completed mixture at the time it is discharged from the mixer. The mixture furnished shall conform to the approved job mix formula within the tolerances specified herein.

JOB MIX TOLERANCES

	<i>Plus or Minus</i>
Aggregate passing sieve No. 4 and larger-----	5 percent
Aggregate passing Nos. 10, 40, and 80 sieves-----	4 percent
Aggregate passing No. 200 sieve-----	2 percent
Asphalt cement-----	0.5 percent
Temperature of mixing and placing-----	25° F.

MATERIALS

408-2.1 AGGREGATE. The aggregate shall consist of a mixture of sand and limestone asphalt with the minimum of twenty (20) percent by weight of limestone asphalt. The sand shall be sound, tough, and durable and be obtained from approved sources. The sand, when combined with the limestone asphalt, shall meet the requirements for gradation given in Table 1 using A. A. S. H. O. Methods T-11 and T-27.

That portion of the aggregate, including any blended filler, passing a No. 40 mesh sieve shall have a plasticity index of not more than 6, as determined by A. A. S. H. O. Method T-91, and a liquid limit of not more than 25, as determined by A. A. S. H. O. Method T-89. The maximum of material passing the No. 200 mesh sieve shall be twelve (12) percent.

The sand shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The bituminized aggregate shall have a swell of not more than one and one-half ($1\frac{1}{2}$) percent as determined by A. A. S. H. O. Method T-101.

Prior to final acceptance of the sand aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample of the paving mixture in conformity with the specifications contained herewith. After the mixture has been made it shall be spread out in a loose thin layer and allowed to air season for twenty-four (24) hours before testing. A suitable size sample (approximately one-half contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap. The sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing off of the bituminous coating occurs it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state, or the sand shall be rejected.

Limestone asphalt shall be pulverized so that not more than five (5) percent is retained on a three-eighths ($\frac{3}{8}$) inch sieve. The limestone asphalt shall be impregnated, by forces of nature, with not less than four (4) percent of bitumen having a penetration at 77° F., 100 gms., 5 sec. of not less than ten (10), and it shall be free from decomposed rock and foreign matter. The natural material furnished shall not be blended or fluxed with any material not included in this specification.

408-2.2 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregate at the central plant shall conform to the specifications as follows:

The asphalt cement for hot central plant mix shall meet the requirements of A. A. S. H. O. Specification M-20 or M-22. The penetration of petroleum asphalt cement shall be between 100 and 150. The penetration of native asphalt cement shall be between 85 and 150. A limited range or grade shall be selected for each project, such as 85-100; 100-120; or 120-150. The penetration grade shall be indicated in the proposal, shown on the plans or as directed by the engineer. The petroleum asphalt cement shall not be cracked.

NOTE: When native asphalt cement contains mineral filler, the penetration grade selected will depend upon the amount of inorganic filler present.

COMPOSITION

408-3.1 COMPOSITION OF MIXTURE. The mineral aggregate for the surface course shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the following gradation:

TABLE 1.—*Requirements for Composition of Mixture*

Sieve size	Percent passing sieves (square openings)
1½-inch.....	100
¾-inch.....	90-100
No. 4.....	75-100
No. 10.....	58- 95
No. 40.....	24- 73
No. 80.....	8- 50
No. 200.....	3- 12
Bitumen percent.....	5- 9

The composition limits tabulated shall govern, but a closer control appropriate to the job materials will be required for the specific project in accordance with a job mix formula. The final gradations decided on within the limits designated in the table shall produce a fairly smooth curve when plotted on semilogarithmic gradation chart.

CONSTRUCTION METHODS

408-4.1 WEATHER AND TEMPERATURE LIMITATIONS. Surface course shall be constructed only when the surface is dry, when the atmospheric temperature is above 40° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

408-4.2 EQUIPMENT. (a) *General.* All methods employed in performing the work, and all equipment, tools, other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The paving plant used by the contractor in the preparation of the bituminous mixture shall comply with the following requirements:

The drier shall be suitably designed to heat and dry the aggregate to specification requirements and to continuously agitate the aggregate during heating. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant to meet the specification requirement. A dial thermometer or other approved thermometric instrument shall be so placed at the discharge chute of the drier as to automatically register or indicate the temperature of the heated aggregate.

The combined aggregate shall be by-passed around any screen on the plant having openings smaller than $\frac{5}{8}$ -inch. The plant shall have storage bins, protected from the weather, of sufficient capacity to furnish the necessary amounts of all aggregates when operating at the maximum rated capacity of the plant. The sand compartment shall be provided with an overflow pipe or other device which meets the approval of the engineer, of such size and at such location as to prevent the sand from backing up or overflowing into any other than sand compartments.

The plant shall have a batch-weighing device for the dried mineral aggregates. This equipment shall be constructed for easy readjustment of any working part so that it will function properly and accurately. The weigh box or hopper shall be supported on fulcrums and knife edges so made that they will not be easily thrown out of alignment or adjustment. The hopper must be free from contact on all edges, ends, or sides with any supporting rods or columns or other equipment that will in any way affect its proper functioning. In addition there must be sufficient clearance between the hopper and supporting devices so that foreign material will not accumulate. The plant shall have a capacity of at least forty (40) tons per hour.

The scales for the weigh box may be either of the beam or springless dial type and shall be a standard make and design, sensitive to one-half ($\frac{1}{2}$) of one (1) percent of the maximum load that may be required. When of the beam type, there shall be a separate beam for each type of material, and there shall be a "telltale" dial scale attached. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. Beam scales shall be balanced on knife edges and fulcrums and be so constructed that they cannot be easily thrown out of alignment

and adjustment. Dial scales shall be of a standard make and of sufficient size that the numerals on the dial can be read at a distance of not less than twenty-five (25) feet. All dial scales shall be so located that they will be in plain view of the operator at all times.

The scales for the weighing of asphalt cement shall conform to the specifications for the aggregate scales, except that beam scales shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not be greater than two (2) pounds. Dial scales for weighing the asphalt cement shall have a capacity of more than twice the weight of the material to be weighed, and shall read to the nearest pound.

The asphalt weigh bucket shall be steam-jacketed or be insulated with other temperature controls. It shall be supported on fulcrums and knife edges in the same manner as the weigh box and have a capacity equal to twelve (12) percent by weight of the maximum capacity of the mixer.

The mixer shall be a standard twin pug-mill type, and of sufficient size to maintain thorough uniform mixing at the rated plant capacity. The mixer shall be equipped with a sufficient number of paddles or blades, and set in the proper order and position to produce a satisfactory mixture of the materials required. When the clearance is equal to or exceeds two (2) inches, either the shortened blades or the worn liners (or both) shall be replaced to reduce the clearance to two (2) inches or less. If sufficient mixing or coating is not secured at the minimum mixing time specified, the right is reserved to increase the required mixing time as may be judged necessary by the engineer. The mixer shall be steam-jacketed or properly insulated with other temperature controls. The capacity of the mixer shall be at least 1,200 pounds.

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

Equipment for heating bituminous material shall consist of kettles or tanks with steam coils or other suitable heating devices. Under no circumstances shall a direct flame come in contact with the heating kettles; steam coils shall be so designed that steam will not be introduced into the material. A recording thermometer shall be provided, which will record the temperature of the bituminous material at the draw-off valve.

Asphalt storage and supply lines shall be insulated or steam-jacketed in such a manner that there will be no appreciable drop in temperature of the asphalt between the heating unit and the mixing unit.

A volumetric proportioning, continuous mixing type of plant may be substituted for the above weigh-batch type when approved by the engineer and provided the equipment has demonstrated that it is suit-

able in producing the required gradation control of aggregates and uniformity of mixture. The number of bin compartments provided shall be the same as stipulated above for batch-type plant. The plant shall include a feeder mounted under the bin compartments and a means of accurately proportioning each bin size of aggregate by accurately controlled individual gate to form an orifice for measuring the material. The orifice shall be rectangular, of dimensions about eight (8) inches by nine (9) inches, with one dimension adjustable by positive mechanical means and provided with a lock. Indicators shall be provided on each gate to show the gate opening in inches. There shall be included a means for calibrating gate openings by means of weight test samples. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be adjustable and, after being set, shall be capable of remaining fixed. The paddles of the continuous mixer shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge, and also giving the rate of feed of aggregate per minute at plant operating speed.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading, shaping, or finishing will be required to provide a surface which will comply with the requirements for thickness and smoothness contained herein.

(d) *Rolling Equipment.* Rollers shall be suitably designed for the construction of bituminous surfaces. The rolling shall be done with self-propelled tandem and three-wheel type rollers weighing not less than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking.

408-4.3 PREPARATION OF AGGREGATE. The sand and limestone asphalt shall be dried and heated at the paving plant before entering the mixer. The aggregate shall contain not more than one (1) percent moisture, and shall show no tendency to sweat after being placed in the storage bins. The materials shall be heated to the temperature as designated by the job formula within the job tolerances specified. The sand and the limestone asphalt may be proportioned by mechanical feeders, or by other means satisfactory to the engineer. The proportion as determined by yield shall not vary more than plus or minus three (3) percent.

Additional filler, if necessary to meet the gradation requirements, shall be proportioned and added to the mineral aggregate.

408-4.4 PREPARATION OF BITUMINOUS MIXTURE. Before being delivered to the runway, the aggregate shall be mixed with the bituminous material at a central mixing plant. The mixture

shall be prepared at a temperature as directed by the engineer between 225° and 300° F.

The dry aggregates, prepared as prescribed above, shall be combined in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer. In case of volumetric proportioning, the size of the gate openings shall be determined and the gates locked in position.

The bituminous material shall be melted in kettles or tanks designed to secure uniform heating of the entire contents. The asphalt cement shall not be heated over 325° F.

Kettles for storage of asphalt cement shall have a total capacity sufficient for one day's run, and shall be capable of heating the asphalt cement with an effective and positive control of the heat at all times to a temperature of between 225° F. and 325° F. Heating of the asphalt cement by steam coils is preferred. The asphalt circulating system shall be constructed of adequate size to give the proper and continuous circulation of asphalt cement throughout the operating periods. All asphalt lines and fittings shall be insulated and heated if necessary.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the engineer, and shall be measured by weight, and introduced into the mixer at the specified temperature, holding to the lowest range possible for adequate mixing and spreading. The exact temperature to be used on the work within the specified range shall be fixed by the engineer. In no case shall aggregate be introduced into the mixture at a temperature more than 25° F. above the temperature of the bituminous material. The mixing shall continue for at least thirty (30) seconds and for such longer period as may be necessary to coat all of the particles.

408-4.5 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be transported from the mixing plant to the point of use in pneumatic-tired vehicles having tight bodies previously cleaned of all foreign materials. When directed by the engineer, each load shall be covered with canvas or other suitable material of sufficient size and thickness to protect it from the weather or dust conditions.

The mixture shall be placed at a temperature between 200° F. and 300° F. When the mixture is being placed during warm weather, and the engineer has determined that satisfactory results can be obtained at lower temperatures, he may direct that the mixture be mixed and delivered at the lower temperatures.

No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during daylight unless artificial light, satisfactory to the engineer, is provided. The mixture shall be delivered at a temperature within the tolerance allowed in the approved job formula.

408-4.6 SPREADING AND LAYING. (a) *Preparation for placing.* Immediately before placing the bituminous mixture, the existing surface shall be cleaned of loose or deleterious material by

sweeping with a power sweeper, supplemented by hand brooms if necessary, or as directed by the engineer.

The mixture shall be laid only upon an approved underlying course which is dry, which is in a suitable condition, and only when weather conditions are suitable. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 40° F. or under unless so directed by the engineer. The engineer may, however, permit work of this character to continue when overtaken by sudden rains, up to the amount which may be in transit from the plant at the time, provided the mixture is within the temperature limits specified.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall commence at the point or points farthest from the mixing plant and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed will not be permitted until the material has been compacted thoroughly in the manner specified, and allowed to cool to atmospheric temperature.

Normally the surface course shall be laid in a layer from one (1) inch to two (2) inches in depth. When the surface course is constructed in thickness greater than two (2) inches, the course shall be placed in two or more layers.

(b) *Machine Spreading.* Upon arrival the mixture shall be dumped into an approved mechanical spreader and immediately spread thereby to the full width required. It shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate the pulling and tearing of the bituminous material.

Placing and compaction of the bituminous mixture shall progress in sections. The bituminous mixture shall be spread, shaped, and finished with the power machine specified. The mixture shall be placed in strips of a minimum width of ten (10) feet. To insure proper drainage, the spreading shall begin along the centerline of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope. The six (6) inch strip adjacent to the area, on which future material is to be laid, shall not be rolled until such material has been placed, but shall not be left unrolled more than two (2) hours after being placed. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted as provided for the first width, except that rolling shall be extended to include the six (6) inches of the first width not previously compacted. Whenever the adjacent or second width cannot be placed within two (2) hours, the six (6) inch strip shall not be left unrolled. After the second strip has been placed and rolled, a straightedge (minimum length of ten (10) feet shall be used across the longitudinal joint to determine if the surface is to grade and contour.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If for any reason the spreading machine should drift away from an adjacent lane during construction, the unfilled space so made shall be carefully filled with fresh hot mixture obtained from the hopper of the spreading machine or from the truck. Stealing mixture from an area already spread to fill up these spaces shall not be permitted.

In limited areas where, on account of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impractical, the mixture may be spread by hand.

When hand spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread, and be distributed into place immediately by means of hot shovels. It shall be spread with hot rakes to a uniform layer to the full width and of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour shown on the plans.

Contact surfaces shall be painted with a thin, uniform coat of hot asphalt cement, cut-back asphalt, or emulsion just before the mixture is placed.

408-4.7 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, the mixture shall be thoroughly and uniformly compressed by a power-driven three-wheel roller and tandem roller or rollers, weighing eight (8) tons or more. Rolling of the mixture shall begin as soon after spreading as it will bear the roller without undue displacement or hair checking. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the other edge.

Initial rolling shall be done longitudinally with tandem rollers and/or three-wheel rollers. The rollers shall overlap on successive trips. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling crossing the lines of the first after three or more lanes are constructed, but cross rolling shall not exceed more than one-half ($\frac{1}{2}$) width of the runway.

The speed of the roller shall at all times be slow enough to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes, and of fresh mixture where required.

Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant. Rolling shall proceed at an average rate not to exceed 350 square yards per hour per roller. Rolling shall continue until all roller marks are eliminated, until the surface is of uniform texture and true to grade and cross section, and until the density of at least ninety (90) percent of the theoretical density is obtained. Field density tests shall be made at least twice daily. Final rolling shall be done with tandem rollers.

The theoretical density shall be computed as follows:

$$\text{Density} = \frac{100}{\frac{\% \text{ mineral aggregate by weight}}{\text{Sp. gr. mineral aggregate}} + \frac{\% \text{ bitumen by weight}}{\text{Sp. gr. of bitumen}}}$$

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated by competent and experienced rollermen. The rollers shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression, and be free from objectionable roller marks.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to final rolling, shall be removed and replaced with fresh mixture which shall be immediately compacted to conform with the surrounding area, all to be done at the expense of the contractor. Skin patching on an area that has been rolled shall not be allowed.

408-4.8 JOINTS. (a) *General.* The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the adjacent course for the full specified depth of the course. Joints shall be formed by cutting back on the previous day's run so as to expose the full depth of the course, and the exposed edge shall be given a light paint coat of asphalt if necessary. The fresh mixture shall be raked against the joint thoroughly tamped with tampers, and rolled.

(b) *Transverse.* The placing of the course shall be as nearly continuous as possible. The roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued.

(c) *Longitudinal.* The placing of the course shall be in the manner as specified and so that the joint is exposed for the shortest period possible. The joint shall be placed so that it will not coincide with that in the base, and will break joints by at least one (1) foot.

408-4.9 SHAPING EDGES. While the surface is being compacted and finished, the contractor shall carefully trim the outside edges of the pavement to the proper alignment. The edges so formed shall be beveled while still hot, with the back of a rake or a smoothing iron, and thoroughly compacted by tampers or by other satisfactory methods.

408-4.10 SURFACE TESTS. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression, and any variation shall be corrected by removing or adding materials and continuing the rolling.

The finished surface shall not vary more than one-fourth ($\frac{1}{4}$) inch for the surface course when tested with a sixteen (16) foot straight-edge applied parallel with or at right angles to the centerline.

After the completion of final rolling, the smoothness of the course shall again be tested, and the humps or depressions exceeding the specified tolerances or that retain water on the surface shall be immediately corrected by removing the defective work and replacing with new material or by adding additional material, as directed by the engineer, and at the expense of the contractor.

408-4.11 SAMPLING PAVEMENT. For the determination of composition, compaction, and density of the pavement, the contractor shall remove suitable size samples of the completed pavement. Samples for each day or fraction thereof, when mixtures are placed, shall be taken by the engineer. The contractor shall replace the pavement where samples are removed, and these replacements shall be installed by the contractor free of charge. After the samples have been removed from the completed pavement they will be tested by the engineer for density and composition. If the deficiency in composition, compaction, and density exceeds the limits of toleration from that specified, satisfactory corrections shall be made.

408-4.12 BITUMINOUS AND AGGREGATE MATERIAL CONTRATOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish materials subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

For checking the adequacy of the equipment in use, inspecting the conditions and operations of the plant, for the verification of weights or proportions and character of materials and/or the determination and checking of temperatures being maintained in the preparation of the mixtures, the engineer or his authorized representative shall have access at any time to all parts of the paving plant.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of bitumen shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

408-4.13 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall he release the car or tank until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

408-5.1 The tonnage of surface course containing at least twenty (20) percent of asphaltic limestone to be paid for shall be the number of tons of bituminous mixture called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

408-5.2 The tonnage of surface course for use on turnarounds, plane marking areas, and other designated areas to be paid for shall be the number of tons of bituminous mixture called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

408-5.3 The unit of measurement for the bituminous material shall be the gallon or the ton, whichever is called for in the bid schedule. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered in the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F., in accordance with A. S. T. M. Designation D-206 for asphalt materials.

BASIS OF PAYMENT

408-6.1 The quantities of surfacing mixture and bituminous material, determined as provided in 5.1, 5.2, and 5.3 above, shall be paid for at the contract unit price per ton in the bid schedule for surface course, and per gallon or per ton for bituminous material, which prices and payment shall constitute full compensation for preparing base; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, rolling, and finishing; for improving unsatisfactory areas; for reconditioning shoulders; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

- Item P-408-6.1 Blended Natural Limestone and Sand Asphalt Surface Course—per ton.
- Item P-408-6.1 Blended Natural Limestone and Sand Asphalt Surface Course (Turnarounds and Parking Areas)—per ton.
- Item P-408-6.1 Bituminous Material—per gallon or per ton.

ITEM P-410 ASPHALT CONCRETE SURFACE COURSE (Liquefier Type)

DESCRIPTION

410-1.1 This item shall consist of a surface course composed of mineral aggregate and bituminous material, mixed in a central mixing plant, and placed on the prepared base course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer.

410-1.2 DETERMINATION OF PERCENTAGE OF BITUMINOUS MATERIAL. The percentage of bituminous material, by weight to be added to the aggregate, shall be fixed by the engineer on the basis of preliminary laboratory tests and field sieve analysis on the aggregate furnished, and shall be within the range as shown in the table.

410-1.3 JOB MIX FORMULA. No work shall be started on the project, nor any mixture accepted therefor, until the contractor has submitted samples of the materials intended for use, and the engineer has established a satisfactory job mix formula based upon tests of the materials furnished. The formula shall be submitted in writing by the engineer to the contractor, indicating the definite percentage for each sieve fraction of aggregate and for bituminous cement; also the temperature of the aggregate at the time it is placed in the mixer. The material furnished shall conform to the approved job mix formula within the tolerances specified herein:

JOB MIX TOLERANCES

	<i>Plus or minus</i>
Aggregate passing sieve No. 4 and larger-----	5 percent
Aggregate passing Nos. 8, 20, and 50 sieves-----	3 percent
Asphalt cement-----	0.4 percent
Liquefier-----	0.2 percent

MATERIALS

410-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed slag, and screenings of these materials. The aggregate and screenings used in any one project shall be the same kind of aggregate.

The surface covering or sealing material shall consist of approved, clean, dry coarse sand. Screenings may be used when approved.

The aggregate shall be tough, durable, and sound. The aggregate shall consist of angular fragments reasonably uniform in density and quality and reasonably free from thin, elongated, or soft pieces, dirt, or other objectionable matter. The coarse aggregate, when tested in accordance with the Los Angeles Rattler Test, after five hundred (500) revolutions shall have a percent of wear of not more than forty-five (45) according to the A. A. S. H. O. Method T-96.

The aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. Slag shall be air-cooled, blast furnace slag, and shall have a compact weight of not less than sixty-five (65) pounds per cubic foot.

The crushed aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent when subject to five (5) cycles of the sodium sulphate soundness test using A. A. S. H. O. Method T-104.

Prior to final acceptance of the proposed aggregate to be used, the inherent characteristics of said aggregate relative to stripping shall be determined. This shall be done by preparing a test sample of the paving mixture in conformity with the specifications contained herewith. After a sample mixture has been made it shall be spread out in a loose thin layer and placed in a constant temperature, oven-controlled to 140° F., for twenty-four (24) hours before testing. A suitable size sample (approximately one-half ($\frac{1}{2}$) contents of container) shall be tested by placing it in a glass jar fitted with a tight screw cap. The sample shall be completely covered with distilled water at a temperature between 80° F. and 100° F. The jar shall be thoroughly cleaned and free from any traces of soap or other saponifiable material. The jar and contents shall be allowed to stand for a period of twenty-four (24) hours. Then the sample shall be vigorously shaken for a period of fifteen (15) minutes. The sample of mixture shall be examined for stripping. If stripping or sloughing off of the bituminous coating occurs it will be necessary to treat said aggregate by a method which has proven successful in changing the material from a hydrophilic to a hydrophobic state, or the aggregate shall be rejected.

410-2.2 BITUMINOUS MATERIAL. The bituminous material to be mixed with the mineral aggregate at the central plant shall conform to the grade, requirements, and specifications as follows:

The asphalt cement shall meet the requirements of the A. A. S. H. O. Specification M-20 or M-22. The penetration of petroleum asphalt cement shall be between 100 and 150. The penetration of native asphalt cement shall be between 85 and 150. A limited range or grade shall be selected for each project, such as 85-100, 100-120, or 120-150. The penetration grade shall be indicated in the proposal, shown on the plans or as directed by the engineer. Petroleum asphalt cement shall not be cracked.

270 410. ASPHALT CONCRETE SURFACE COURSE

NOTE: When native asphalt cement contains mineral filler, the penetration grade selected will depend upon the amount of inorganic filler present.

410-2.3 LIQUEFIER. The liquefier shall meet the requirements of the A. A. S. H. O. Specification M-83. The grade shall be the light grade unless otherwise indicated in the proposal.

410-2.4 HYDRATED LIME. The hydrated lime shall meet the requirements of the A. S. T. M. Designation C-6.

COMPOSITION OF MIXTURE

410-3.1 GRADATION. The mineral aggregate for the surface course and sealing material shall be of such size that the composition by weight, as determined by laboratory sieves, shall conform to the following gradations:

Sieve size	Percent passing sieves (square openings)	
	Aggregate	Sealing material
¾-inch.....	100	-----
½-inch.....	95-100	-----
No. 4.....	15- 40	100
No. 8.....	10- 25	-----
No. 20.....	5- 15	-----
No. 50.....	0- 5	10- 30
No. 100.....	-----	0- 15

410-3.2 COMPOSITION. The mineral aggregates and other ingredients shall be combined within the following percent by weight as may be directed by the engineer:

Materials	Stone aggregate		Slag aggregate	
	Min.	Max.	Min.	Max.
Mineral aggregate.....	90.5	94.0	89.0	93.0
Liquefier.....	0.5	1.5	0.5	1.5
Asphalt cement.....	5.0	7.0	6.0	8.5
Hydrated lime.....	0.5	1.0	0.5	1.0

The sealing material shall be prepared in the paving plant and be proportioned by weight, as directed by the engineer.

	Percent
Asphalt Cement.....	2.0 to 3.5
Sand.....	96.5 to 98
Liquefier.....	0.5 to 1.5

CONSTRUCTION METHODS

410-4.1 WEATHER LIMITATIONS. Surface course shall be constructed only when the surface is dry, when the atmospheric temperature is above 50° F., and when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

410-4.2 EQUIPMENT. (a) *General.* All methods employed in performing the work and all equipment, tools, other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The paving plant used by the contractor in the preparation of the surface course shall comply with the following requirements:

The plant shall include a drier capable of heating evenly the aggregate necessary to continuously supply the mixing unit at its operating capacity, and of removing moisture from the aggregate to the limit herein prescribed without burning or overheating any portion. The equipment for mechanical cooling of the drying aggregate to the temperature prescribed for mixing shall be used, of capacity ample to keep the mixer supplied at its operating capacity, except in plants provided with dry, enclosed, storage space and mechanical aerating equipment adequate to accomplish satisfactorily the specified cooling of the dried aggregates without sweating or other deconditioning; in such plants, driers complying with all requirements except capacity, shall be used. For plants designed for mechanical cooling supplemented by dry storage, the requirements for mechanical aerating of the aggregate as it is being stored may be waived for material entering the storage space at atmospheric temperature.

The plant shall have storage bins, protected from the weather, of sufficient capacity to furnish the necessary amounts of all aggregates when operating at the maximum rated capacity of the plant. The bins shall provide two or more compartments, so proportioned as to insure adequate storage of appropriate fractions of the aggregate and mineral filler. Each compartment shall be provided with an overflow pipe or other device which meets the approval of the engineer, of such size and at such locations as to prevent backing-up of material into other compartments. All aggregate shall be dried and, after drying, shall be stored in the respective compartment where it can be held or fed to the weigh box. The storage of dried aggregate in the open-air or under tarpaulin covers will not be permitted, and dried aggregate may be stored only in covered bins as herein provided. The plant shall have a capacity not less than twenty-five (25) tons of mixed material per hour based on continuous operation.

The plant shall have a weigh box of such capacity to hold a maximum amount of material for one batch, not less than 2,000 pounds.

The weigh box or hopper shall be supported on fulcrum and knife edges so constructed that they will not be easily thrown out of alignment or adjustment. Said weighing hoppers must be free from contact on all edges, ends, or sides with any supporting rods or columns or other equipment that will in any way affect its proper functioning. In addition there must be sufficient clearance between the hopper and supporting devices so that foreign materials will not accumulate. The discharge gate of the weigh box shall be so hung that the aggregates will not be segregated when dumped in the mixer. If necessary to correct any such tendency, baffles shall be inserted or other means provided to discharge the materials in a blended condition. The discharge gate shall be sufficiently tight to prevent leakage of fine aggregate into the mixer.

Scales for the weigh box may be either of the beam or springless dial type and shall be of a standard make and design, sensitive to one-half ($\frac{1}{2}$) percent of the maximum load that may be required. When of the beam type, there shall be a separate beam for each kind of material, and there shall be a "telltale" dial scale attached which will start to function when the load being applied is within one hundred (100) pounds of that desired. Sufficient vertical movements shall be provided for the beams to permit the "telltale" dial scale to function properly. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. Beam scales shall be balanced on knife edges and fulcrums, and be so constructed that they cannot be easily thrown out of alignment and adjustment.

Dial scales shall be of a standard make and of sufficient size that the numerals on the dial can be read at a distance of not less than twenty-five (25) feet. The dials shall be of the compounding type having full complement of index pointers. Any pointers so placed as to give excessive parallax errors shall not be used. The scales shall be substantially constructed, and makes of this type of scale which easily get out of adjustment shall be replaced with other makes when so ordered. All dial scales shall be so located that they will be in plain view of the operator at all times.

Scales for the weighing of asphalt cement shall conform to the specifications for the aggregate scales except that beam scales shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not be greater than two (2) pounds. Dial scales for weighing the asphalt cement shall not have a capacity of more than twice the weight of the material to be weighed, and shall read to the nearest pound.

The asphalt weigh bucket shall be steam-jacketed and have a capacity equal to ten (10) percent of the maximum capacity of the mixer. It shall be supported on fulcrums and knife edges in the same manner as the weigh box.

Tanks for storage of asphalt cement shall have a total capacity sufficient for one (1) day's run, and shall be capable of heating the asphalt cement with an effective and positive control of the heat at all times

to a temperature of between 225° F., and 325° F. Under no circumstances shall a direct flame from oil or other fuel be permitted to come in direct contact with the heating kettles. The asphalt circulating system shall be constructed of adequate size to give the proper and continuous circulation of asphalt cement throughout the operating periods. All asphalt lines and fittings shall be steam-jacketed or sufficiently insulated.

An armored thermometer reading from 200° F. to 400° F. shall be fixed in the asphalt line at a suitable location near the weigh bucket discharge valve.

The plant shall be equipped with an approved dial scale mercury actuated thermometer, an electric pyrometer, or other approved thermometric instrument, so placed at the discharge chute of the drier as to automatically register the temperature of the aggregates. The engineer reserves the right to pass upon the efficiency of this instrument, and for better regulation of temperature of the aggregates may direct the replacement by some other approved temperature recording apparatus, and may further require that the daily temperature charts be filed with the engineer. Unless otherwise approved by the engineer, suitable approved means shall be provided to determine that the temperature of the aggregate is not above that specified at the time the aggregate is placed into the mixer.

There shall be an accurate calibrated device installed for the measurement of liquefier, and the discharge pipes from such device shall be installed to spray liquefier into the mixer in such a manner that a uniform distribution of same will result.

The mixer shall be of the pug-mill type, having a capacity of a 2,000 pound batch or larger, and of a design to permit visual inspection of the condition of the mix; it shall be suitably heated for efficient mixing. For the minimum mixing time of two (2) minutes, hereinafter prescribed for a mixer capacity of 2,000 pound batch, if sufficient mixing and coating is not secured the right is reserved to increase the required mixing time as may be judged necessary by the engineer. The mixer shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the aggregate is introduced into an operating mixer and the time the same aggregate leaves the mixing unit.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading, shaping, or finishing will be required to provide a surface which will comply with the requirements for smoothness contained herein.

(d) *Rolling Equipment.* Rollers shall be suitably designed for the construction of bituminous surfaces. The rolling shall be done with self-propelled tandem and three-wheel type rollers weighing not less than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprin-

kling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking.

410-4.3 PREPARATION OF BITUMINOUS MATERIAL.

The bituminous material shall be heated in the melting kettles or tanks so as to secure even heating of the entire mass. The material shall be heated to between 200° F. and 300° F., as directed.

410-4.4 PREPARATION OF AGGREGATES. The aggregate for the surface course shall be dried to the extent that it has no surface moisture and not more than one-half ($\frac{1}{2}$) percent by weight of contained moisture. Mixing temperatures of the aggregate shall at no time be less than 50° F. nor more than 110° F.; except that the engineer may direct the upper limit to be raised to 125° F. when using slag aggregate.

410-4.5 PREPARATION OF MIXTURE. The mineral aggregate, asphalt cement, and other ingredients shall be thoroughly mixed in a central mixing plant. The required quantities of the various materials entering into the composition of the mix shall be measured separately and accurately.

When asphalt cement and liquefier are used with stone as the mineral aggregate, the materials shall be introduced into the mixer in the following order: stone, liquefier, asphalt cement, and lime. When slag is used as the mineral aggregate, the sequence of additions of the ingredients shall be as follows: slag, asphalt cement, liquefier, and lime. A sufficient interval of time shall be allowed to elapse after the addition of each material to allow thorough incorporation prior to the introduction of the next ingredient.

The dried mineral aggregate, drawn from the bins, combined in batches by weighing if there are separated sizes, shall be conveyed to the empty mixer. The aggregate shall be mixed dry for a period sufficient to uniformly distribute the various sizes throughout the batch, after which the liquefier shall be sprayed over the aggregate. The liquefier shall be sprayed over the whole mass and not deposited at one point. The mixing shall continue until the stone is coated. The quantity of liquefier used shall be varied within the limits herein set forth, depending on the weather, time, and distance the mixture is to be transported, and shall be used in such a manner as will insure the desired consistency of mixture when it is delivered on the project.

The asphalt cement and hydrated lime shall then be successively introduced and the mixing continued until mixture is thoroughly uniform and homogeneous in character. These materials shall likewise be introduced in such a manner that they will be equally distributed over the whole mass. The mixture, when mixing is completed, shall be uniform in composition, free from lumps or balls of material containing an excess quantity of asphalt, and free from pockets containing less asphalt than required.

The dry mixing period and mixing interval between the introduction of ingredients shall be set by the engineer in relation to the aggregates used, and the total mixing time will vary in relation to the nature of the aggregates, the capacity and efficiency of the mixer, but in no case

shall any mixing increment be less than fifteen (15) seconds and the total mixing time be less than two (2) minutes after the introduction of the aggregate into the mixer. The mixture shall be so prepared that it may be unloaded and applied at the prevailing temperature on the project, down to a temperature of 50° F. without application of heat. Within the above requirements the details of plant operation shall be arranged to produce the workability of mix and the thickness of film coating found most advantageous.

When approved, hydrated lime may be measured by volume. When slag is used as aggregate, the introduction of the asphalt cement and liquefier as described above, shall be reversed.

The sealing material shall be prepared in the central plant under the same temperature, measuring, and mixing controls. The mineral aggregate shall not contain more than three (3) percent moisture at the time it is introduced into the mixer.

410-4.6 TRANSPORTATION AND DELIVERY OF MIXTURE. The mixture shall be transported from the mixing plant, or from the unloading point, to the project in pneumatic-tired vehicles having tight bodies previously cleaned of all foreign matter. The trucks shall be covered with waterproof canvas covers or other approved covers when so ordered. The inside surface of the trucks may be thinly coated with a soapy water, or lubricating oil. The use of any type of solvent such as kerosene, gasoline, or similar products will not be permitted.

When it is necessary to ship the mixture by car, all unloading shall be done under the direction of the engineer. To facilitate unloading from cars, the surface mixture may be steamed. Steam pressure shall be low and not exceed twenty (20) pounds per square inch at any time. The use of any mixture excessively steamed or contaminated with foreign materials shall not be allowed.

Any truck loads or shipments found to contain a surplus amount of bituminous material in the bottom of the transporting vehicle shall be rejected upon arrival. The dispatching of trucks to the project shall be arranged so that all mixtures delivered may be spread and compacted during daylight, unless artificial light satisfactory to the engineer is provided. Mixture for the surface course and the surface covering material shall be mixed and transported separately.

410-4.7 SPREADING AND LAYING. (a) *Preparation for placing.* The bituminous surface shall be placed only on an approved underlying course which is dry and which has been properly prepared and consolidated. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 50° F. or under, unless so directed by the engineer. When rains overtake the placing, the work shall be stopped and held up until the base and mixture have dried.

Prior to the arrival of the bituminous mixture, the underlying course shall have been brought to exact lines, grade, and cross section, and shall be cleaned of all loose and foreign material by sweeping with power sweepers equipped with blowers or hand brooms if necessary,

or as directed. A tack coat shall be applied to the base course when and as directed at the rate specified.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins. The elevation of the grade stakes or pins shall be checked immediately before placing the mixture.

Placing shall commence at the point or points furthest from the mixing plant, and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed will not be permitted until the material has been compacted thoroughly in the manner specified.

Contact surfaces shall be painted with a thin, uniform, coat of asphalt cut-back just before the mixture is placed.

(b) *Machine Spreading.* Upon arrival, the mixture shall be dumped into an approved mechanical spreader and immediately spread thereby to the full width required. It shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate as far as possible the pulling and tearing of the bituminous material.

Placing and compaction of the bituminous mixture shall progress in sections. The bituminous mixture shall be spread, shaped, and finished with the power machine specified. The mixture shall be placed in strips of a minimum width of ten (10) feet. To insure proper drainage, the spreading shall begin along the center line of the runway or taxiway on a crowned section or on the high side of the pavement with a one-way slope. The six (6) inch strip adjacent to the area on which future material is to be laid shall not be rolled until such material has been placed, but shall not be left unrolled more than twenty-four (24) hours after being placed. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted as provided for the first width, except that rolling shall be extended to include the six (6) inches of the first width, not previously compacted. Whenever the adjacent or second width cannot be placed within twenty-four (24) hours, the six (6) inch strip shall not be left unrolled. After the second strip has been placed and rolled, a straightedge (minimum length of ten (10) feet) shall be used across the longitudinal joint to determine if the surface is to grade and contour.

(c) *Hand Spreading.* In limited areas where, on account of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impractical, the mixture may be spread by hand.

When hand-spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread and be distributed into place immediately by means of shovels. It shall be spread in a uniformly loose layer to the full width

required and of such depth that, where the work is completed, it will have the required thickness and will conform to the grade and surface contour required.

(d) *Layers.* The surface course shall be constructed in a layer of not less than one (1) inch and not more than two (2) inches in thickness. When greater thicknesses are required, the surface shall be laid in layers as directed, and the procedure described herein shall apply similarly to each layer.

410-4.8 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, the mixture shall bear thoroughly and uniformly compressed by a power-driven three-wheel roller and tandem roller or rollers weighing eight (8) tons or more. Rolling of the mixture shall begin as soon after spreading as it will be the roller without undue displacement or shoving. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the other edge.

Initial rolling shall be done longitudinally with powered rollers overlapping on successive trips of the roller. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling crossing the lines of the first.

The speed of the roller shall at all times be slow enough to avoid displacement of the mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes, and of fresh mixture where required.

Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant or the rate of delivery on the work. Rolling shall proceed at an average rate not to exceed 350 square yards per hour per roller. Rolling shall continue until all roller marks are eliminated, until the surface is of uniform texture and true to grade and cross section, and until the density satisfactory to the engineer is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated by competent and experienced rollermen. The rollers shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to the application of the finished coat, shall be removed and replaced with fresh mixture, which shall be imme-

diately compacted to conform with the surrounding area, all to be done at the expense of the contractor.

410-4.9 SURFACE COVERING. After rolling is completed as described, a surface covering of treated material shall be spread uniformly over the surface. An even distribution can be obtained by the use of wooden lutes. Only sufficient covering shall be used to fill the surface voids in the pavement. After spreading, the covering shall be thoroughly rolled. The furnishing, application, and rolling of the cover shall be included in the price bid per ton for the asphalt concrete surfacing.

410-4.10 JOINTS. The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the new surface for the full specified depth of the course. Joints may be formed by cutting back of the previous day's run so as to expose the full depth of the course, and the fresh mixture raked against the joint, and thoroughly rolled.

410-4.11 SHAPING EDGES. While the surface is being compacted and finished, the contractor shall trim the edges of the pavement neatly to line.

410-4.12 SURFACE TESTS. The finished surface shall not vary more than one-quarter ($\frac{1}{4}$) inch for the wearing course when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the centerline. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression by powered rollers, and any variation shall be corrected by removing or adding materials and continuing the rolling. After the completion of final rolling, the smoothness of the course shall again be tested, and the humps or depressions exceeding the specified tolerances or that retain water on the surface shall be corrected by removing the defective work and replacing with new material, or by adding additional material as directed by the engineer at the expense of the contractor.

410-4.13 BITUMINOUS AND AGGREGATE MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous and aggregate materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such material begins. The contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

For checking the adequacy of the equipment in use, inspecting the conditions and operation of the plant, for the verification of weights or proportions and character of materials and/or the determination and checking of temperatures being maintained in the preparation of

the mixtures, the engineer or his authorized representative shall have access at any time to all parts of the paving plant.

The contractor shall furnish vendor's certified test report for each carload or equivalent of asphalt cement shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as the basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

410-4.14 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

410-5.1 The tonnage of asphalt concrete surface course to be paid for shall be the number of tons of bituminous mixture of the type as called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing and no deduction shall be made for the weight of bituminous material in the mixture.

410-5.2 The bituminous material and other ingredients shall not be paid for separately but shall be included in the price bid for surface course above, and shall be considered incidental to the price for this item.

BASIS OF PAYMENT

410-6.1 The quantities of asphalt concrete surface mixture, determined as provided in 5.1 and 5.2 above, shall be paid for at the contract unit price per ton in the bid schedule for surface course, which price and payment shall constitute full compensation for preparing base; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, and rolling; for finishing; for improving unsatisfactory areas; for reconditioning base and shoulders; for furnishing and applying surface cover; for furnishing and sealing of scales; for furnishing the weigh house; for all labor, equipment, tools, and incidentals necessary to complete the item, except any prime or tack coat.

Payment will be made under:

Item P-410-6.1 Asphalt Concrete Surface Course—per ton.

ITEM P-411 SURFACE TREATMENT WITH BLENDED NATURAL LIMESTONE AND SAND ASPHALT MIXTURE (Central Plant—Cold Laid)

DESCRIPTION

411-1.1 This item shall consist of a surface treatment composed of natural asphaltic limestone and sand asphalt mixture, mixed in a central plant, and laid cold and placed on a prepared underlying course in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer.

MATERIALS

411-2.1 AGGREGATES. The sand shall be sound, tough, and durable and be obtained from approved sources. The sand shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter that will prevent thorough coating with bituminous material. The sand shall be so graded that not more than five (5) percent will be retained on a No. 4 mesh sieve, and not more than twenty-five (25) percent will pass a No. 40 mesh sieve.

The asphaltic limestone shall be uniform and well-graded, and shall contain not less than four (4) percent of native asphalt. It shall be so crushed that not more than ten (10) percent will be retained on a one-half ($\frac{1}{2}$) inch sieve.

Approval of the sources of supply of the mineral aggregates shall be obtained from the engineer prior to the delivery of the surface treatment material, and samples shall be submitted when requested by the engineer.

411-2.2 BITUMINOUS MATERIAL. The asphaltic flux shall consist of an asphalt cement meeting the requirements of A. A. S. H. O. Specification M-20. The penetration of the asphalt cement shall be between 150 and 200.

411-2.3 LIQUEFIER. The liquefier shall conform to the requirements of A. A. S. H. O. Specifications M-83. The grade of liquefier shall be the light grade.

CONSTRUCTION METHODS

411-3.1 WEATHER AND TEMPERATURE LIMITATIONS. The surface treatment shall be constructed only when the surface is dry, when the atmospheric temperature is above 45° F., and

when the weather is not foggy or rainy. The temperature requirement may be waived, but only when so directed by the engineer.

411-3.2 EQUIPMENT. (a) *General.* All methods employed in performing the work and all equipment, tools, other plant and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started, and whenever found unsatisfactory shall be changed and improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

(b) *Mixing Plant.* The mixing plant used by the producer in the preparation of the bituminous mixture shall comply with the following requirements:

The drier, if necessary, shall be suitably designed to heat and dry the aggregate to specification requirements and to continuously agitate the aggregate during heating. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant to meet the specification requirement. A dial thermometer or other thermometric instrument shall be so placed in the bin over the mixer as to automatically register the temperature of the heated aggregate before it enters the mixer. The dial or other indicator shall be plainly visible from the mixing platform.

The combined aggregate shall be bypassed around any screen on the plant having openings smaller than five-eighths ($\frac{5}{8}$) inch. The plant shall have storage bins, protected from the weather, of sufficient capacity to furnish the necessary amounts of all aggregates when operating at the maximum rated capacity of the plant.

The plant shall have batch weighing of mineral aggregates and asphalt cement. This equipment shall be constructed with devices that will permit easy readjustment of any working part, such that it will function properly and accurately. The aggregate weighing device shall be so constructed and operated that the correct amount of each aggregate is introduced into the mixer with an accuracy that will meet the job tolerances specified.

The asphalt weighing device shall be so constructed and operated that the correct amount of asphalt is introduced into the mixer with an accuracy that will meet the job tolerance. The dial scales or other weighing device shall be of an approved type.

The mixer shall be a twin pug-mill mixer of sufficient size to maintain thorough, uniform mixing at the rated plant capacity.

The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed by order of the engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

(c) *Placing Equipment.* Equipment for spreading, shaping, and finishing shall consist of an approved self-contained power machine operating in such a manner that no supplemental spreading,

shaping, or finishing will be required to provide a surface which will comply with the requirements for smoothness contained herein.

The motor grader shall be a modern unit, weighing not less than five (5) tons, and equipped with a mould board of at least twelve (12) feet in length. The grader shall be in good condition with the joints and connections, especially on the mould board and controls, tight and free from lost motion.

(d) *Rolling Equipment.* Rollers shall be suitably designed for the construction of bituminous surfaces. The rollers shall be self-propelled tandem and three-wheel type rollers weighing not less than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surface. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing material from sticking.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

411-3.3 PREPARATION OF AGGREGATES. The sand shall be dried, if necessary, but shall not be heated over 200° F., and shall not contain more than two (2) percent moisture when placed in the mixer. The asphaltic limestone shall not be heated. The sand and the asphaltic limestone shall be placed in the bins at the paving plant and combined in the correct proportions when drawn from the bins for mixing. When possible, the sand shall be allowed to cool before mixing.

411-3.4 PREPARATION OF BITUMINOUS MIXTURE. Before being delivered to the runway, the aggregates shall be mixed with the bituminous material at a central mixing plant. The aggregates prepared, as prescribed above, shall be accurately measured and conveyed into the mixer in the proportionate amounts of each material required to meet the specified requirements. The amount of sand to be used in the mixture may be varied from twenty-five (25) to fifty (50) percent by weight. The exact amount shall be as stated in the proposal.

The bituminous material shall be stored in tanks of suitable capacity, and so located that the asphalt can be conveyed into the batch-weighting device.

The liquefier may be combined with the asphalt cement before shipment from the refinery, or may be introduced into the mixture at the central mixing plant. In either case, the amount of liquefier shall be between fifteen (15) and twenty (20) percent by weight of the asphalt cement used or added at the mixer.

If the liquefier is premixed with the asphalt cement, the asphalt shall not be heated above 160° F. If the asphalt cement is kept separate from the liquefier, the cement shall be heated to a temperature of not more than 275° F.

The quantity of bituminous material for each batch shall be determined and shall be measured by weight and introduced into the mixer. The surface treatment mixture shall have a total bitumen content of not less than six (6) nor more than nine (9) percent. The mixing shall continue for at least thirty (30) seconds, and for such longer period as may be necessary to coat all of the particles.

411-3.5 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be transported to the point of use in equipment having tight bodies previously cleaned of all foreign materials. When directed by the engineer, each load shall be covered with canvas or other suitable material of sufficient size and thickness to protect it from the weather conditions and dust.

No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixture during daylight, unless artificial light satisfactory to the engineer is provided.

411-3.6 SPREADING AND LAYING. (a) *Preparation for Placing.* Immediately before placing the bituminous mixture, the existing surface shall be cleaned of loose or deleterious material by sweeping with a power sweeper equipped with a blower, supplemented by hand brooms if necessary, or as directed by the engineer.

The mixture shall be laid only upon an approved underlying course which is dry, and only when weather conditions are suitable. No mixture shall be placed when the air temperature in the shade and away from artificial heat is 45° F. or under, unless so directed by the engineer. In event of sudden rains, no more mixture in transit shall be dumped into the spreading machine. All work shall be stopped and the mixture that has been spread but not compacted by rolling shall be allowed to dry out.

Grade control between the edges of the runway shall be by means of grade stakes or steel pins placed in lanes parallel to the centerline of the runway, and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall commence at the point or points furthest from the mixing plant, and progress continuously toward the plant, unless otherwise ordered by the engineer. Hauling over material already placed will not be permitted until the material has been compacted thoroughly in the manner specified.

The surface treatment mixture shall be placed on keystone mat (Item P-405) course or on an existing course, when directed. In either case a bituminous tack course, in accordance with Item P-603, shall be placed and allowed to cure for not less than two (2) hours prior to spreading the surface treatment.

(b) *Machine Spreading.* Upon arrival the mixture shall be dumped into an approved mechanical spreader and immediately

spread thereby to the full width required. It shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. The speed of the mechanical spreader shall be regulated to eliminate as far as possible the pulling and tearing of the bituminous material.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If for any reason the spreading machine should drift away from an adjacent lane during construction, the unfilled space so made shall be carefully filled with fresh mixture obtained from the hopper of the spreading machine, or from a truck. Stealing mixture from an area already spread to fill up these spaces shall not be permitted.

(c) *Grader Spreading.* When approved by the engineer, the surface mixture shall be spread by motor graders. The mixture shall be placed by trucks along the centerline of a strip twenty (20) feet to thirty (30) feet wide, in amounts per linear foot of the strip to result in correct pounds per square yard of mixture, as shown on the plans or as directed by the engineer.

The material shall be windrowed by the grader in a uniform section of the windrow. The material shall then be spread by successive trips of the grader by blading portions of the windrow over the entire width of the strip under construction. Care shall be taken not to blade too low to cut into the underlying surface, and also to spread the mixture uniformly in order to place the correct thickness at all points. After the second or third trip of the blader along the windrow, rubber-tired rollers shall be used and shall follow behind the grader on every trip. The mixture shall be spread gradually and rolled until all the material in the windrow has been spread.

A clapboard drag shall be used on any sections found to contain lumps, either during or following the blading operations. Any depressions or low areas that show up after spreading and rolling shall be brought up to even finish or contour by depositing additional mixture from a truck on such areas and by additional spreading by dragging, blading, and rolling.

(d) *Hand Spreading.* When hand spreading is permitted, the mixture shall be dumped upon arrival on approved dump sheets outside of the area on which it is to be spread, and be distributed into place immediately by means of shovels. It shall be spread with rakes to a uniform layer to the full width and of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour. The final shaping before rolling shall be done with a light blade maintainer. Alternate blading and rolling shall be done with the maintainer and pneumatic rollers during the process of compaction.

(e) *General.* The amount of the surface treatment mixture to be placed shall be between fifty (50) and one hundred and fifty (150) pounds per square yard, as called for in the proposal or as directed by the engineer.

Contact surfaces shall be painted with a thin, uniform coat of asphalt cut-back just before the mixture is placed.

411-3.7 COMPACTION OF MIXTURE. After spreading, and as directed by the engineer, the mixture shall be thoroughly and uniformly compressed by rolling. Rolling of the mixture shall begin as soon after spreading as is practicable. Pneumatic rollers shall be used for the initial rolling.

The initial rolling shall be done longitudinally with overlapping on successive trips of the roller. Sufficient rollers of the designated types shall be furnished to adequately handle the rate of spreading. Rolling shall proceed at an average rate not to exceed 500 square yards per hour per roller.

Final rolling shall be done with powered rollers. Rolling shall continue until all roller marks are eliminated, until the surface is of uniform texture, true to grade and cross section, and until the density of at least ninety (90) percent of the theoretical density is obtained. Field density tests shall be made twice daily.

Alternate trips of the powered rollers shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling crossing the lines of the first. The speed of the roller shall at all times be slow enough to avoid displacement of the mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes, and of fresh mixture where required.

The wheels of the roller shall be kept properly moistened to prevent adhesion of the mixture to the wheels, but an excess of either water or oil will not be permitted. The rollers shall be kept in good condition and shall be operated by competent and experienced rollermen. The rollers shall be operated continuously as far as practicable and in such a manner that all parts of the pavement shall receive substantially equal compression.

At all places not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Hand tampers shall weigh not less than twenty-five (25) pounds and shall have a tamping face area of not more than fifty (50) square inches. The surface of the mixture after compression shall be smooth and true to the established crown and grade.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective prior to final rolling, shall be removed and replaced with fresh mixture, which shall be immediately compacted to conform with the surrounding area, all to be done at the expense of the contractor. Skin patching on an area that has been rolled shall not be allowed.

411-3.8 JOINTS. The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the new surface for the full specified depth of the course. Joints shall be formed by cutting back on the previous day's run so as to expose the full depth of the course, and the exposed edge shall be given a light paint coat of asphalt, if necessary. The fresh mixture shall be raked against the joint, thoroughly tamped with tampers, and rolled.

411-3.9 SURFACE TESTS. The finished surface shall not vary more than one-quarter ($\frac{1}{4}$) inch for the surface course when tested with a sixteen (16) foot straightedge applied parallel with or at right angles to the centerline. Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression, and any variation shall be corrected by removing or adding materials and continuing the rolling. After the completion of final rolling the smoothness of the course shall again be checked, and the humps or depressions exceeding the specified tolerances, or that retain water on the surface, shall be corrected by removing the defective work and replacing with new material or by adding additional material, as directed by the engineer, and at the expense of the contractor.

411-3.10 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills, where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and paving materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

411-4.1 The tonnage of surface treatment mixture to be paid for shall be the number of tons of bituminous mixture placed at the amount per square yard called for in the bid schedule and used in the accepted work. The bituminous-treated material shall be weighed after mixing, and no deduction shall be made for the weight of bituminous material in the mixture.

The bituminous material and liquefier shall not be paid for separately but shall be included in the price bid for surface treatment mixture above, and shall be considered incidental to the price for this item.

BASIS OF PAYMENT

411-5.1 The quantities of surface treatment mixture, determined as provided in 4.1 above, shall be paid for at the contract unit price per ton in the bid schedule for surface treatment, which price and payment shall constitute full compensation for preparing underlying course; for furnishing, handling, mixing, manipulating, and placing all materials; for all shaping, compacting, rolling, and finishing; for improving unsatisfactory areas; for reconditioning shoulders; for furnishing samples; for furnishing and sealing of scales; for furnishing the weigh house; and for all labor, equipment, tools, and incidentals necessary to complete the item, except any tack coat.

Payment will be made under:

Item P-411-5.1 Surface Treatment—per ton.

RIGID PAVEMENT

ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

(Plain and Reinforced)

DESCRIPTION

501-1.1 This item shall consist of a wearing surface of either plain or reinforced Portland cement concrete pavement, as designated on the plans and constructed on the prepared underlying course, in accordance with these specifications and in conformity with dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer. The concrete shall be composed of coarse aggregate, fine aggregate, Portland cement, and water.

MATERIALS

501-2.1 AGGREGATES, GENERAL. In no case will the use of pit run or naturally mixed coarse aggregates be permitted. Naturally mixed aggregate must in every case be screened and washed, and all fine and coarse aggregates must be stored separately and shall be kept clean. The mixing of different kinds of aggregates from different sources in one storage pile, or alternating batches of different aggregates, will not be permitted. In no case shall aggregates containing lumps of frozen or partially cemented material be used.

501-2.2 COARSE AGGREGATE. The coarse aggregate shall conform to the requirements of A. A. S. H. O. Specification M-80. The percentage of wear, Los Angeles Rattler Test, shall not be more than 50.

The coarse aggregate shall not have more than one (1) percent of material removable by the decantation test, using A. A. S. H. O. Method T-11, nor more than one (1) percent of shale using A. A. S. H. O. Method T-10, nor more than five (5) percent of soft fragments, nor more than one-fourth ($\frac{1}{4}$) of one (1) percent of clay lumps. The total of shale, coal, clay lumps, and soft fragments shall not be more than five (5) percent.

In addition to the sodium sulphate accelerated soundness test, the coarse aggregate shall have a record of satisfactory and successful use in concrete construction for a period of at least three (3) years. In cases where new quarries are recently developed, the engineer may waive this requirement.

The coarse aggregate shall meet the gradation of either Table 1 or 2. The coarse aggregate shall be stock piled and batched in two separate sizes.

TABLE 1.—*Gradations From 2-inch to No. 4*

Sieve designation	Percentage by weight passing square mesh sieves, in inches (A. A. S. H. O. T-27)						
	2½	2	1½	1	½	No. 4	No. 8
2-inch to 1-inch.....	100	90-100	35- 70	0- 15	0- 5	-----	-----
1-inch to No. 4.....	-----	-----	100	90-100	25-60	0-10	0-5

TABLE 2.—*Gradations From 1½-inch to No. 4*

Sieve designation	Percentage by weight passing square mesh sieves, in inches (A. A. S. H. O. T-27)						
	2	1½	1	¾	¾	No. 4	No. 8
1½-inch to ¾-inch.....	100	90-100	20- 55	0- 15	0- 5	-----	-----
¾-inch to No. 4.....	-----	-----	100	90-100	20-55	0-10	0-5

In Table 1 or Table 2 the ratio of either separated size of coarse aggregate to total coarse aggregate may be varied within the range of forty (40) to sixty (60) percent by weight to secure the most desirable and uniform gradation of the combined mix.

501-2.3 FINE AGGREGATE. The fine aggregate shall conform to the requirements of A. A. S. H. O. Specification M-6.

When subjected to five (5) cycles of the sodium sulphate soundness test the fine aggregate shall have a total loss not greater than ten (10) percent by weight. Instead of the soundness test mentioned above, the contractor may provide evidence, satisfactory to the engineer, that the fine aggregate has been exposed to natural weathering, either directly or in concrete, for a period of at least five (5) years without appreciable disintegration.

Fine aggregate shall contain not more than three (3) percent of material removable by a decantation test, using A. A. S. H. O. Method T-11, nor more than one (1) percent of clay lumps, or one (1) percent of shale, as determined by A. A. S. H. O. Method T-10. The total of coal, clay lumps, shale, soft fragments, and other local deleterious substances shall not be more than five (5) percent.

The percentage of clay lumps shall be determined by examining the various fractions that remain after the material has been tested for grading. Any particles that can be broken up with the fingers shall be classified as clay lumps, and the total percentage by weight of all

clay lumps shall be determined on the basis of the total original weight of the sample.

The fine aggregate shall be well-graded from fine to coarse, and shall meet the following gradation requirements, using A. A. S. H. O. Method T-27.

TABLE 3.—*Gradation for Fine Aggregate*

Sieve designation	Percentage by weight passing square mesh sieves
3/4-inch.....	100
No. 4.....	95-100
No. 16.....	45- 80
No. 30.....	25- 55
No. 50.....	10- 30
No. 100.....	2- 10

Blending will be permitted, if necessary, in order to meet the gradation requirements for fine aggregate.

501-2.4 CEMENT. The cement used in the work shall be a standard brand of Portland cement, a standard brand of high early strength Portland cement, a standard brand of moderate sulfate-resisting cement, or a standard Portland cement with air-entraining properties. Portland cement shall conform to the standard specification of A. S. T. M. Designation C-150. Air-entrained cement shall conform to A. S. T. M. Designation C-175. Only one brand of each shall be used on any one job, except by specific written permission from the engineer. The contractor shall provide suitable means for storing cement and protecting it from dampness. Different grades and brands of cement shall be stored separately, and shall not be mixed.

Where so indicated on the plans, high-early-strength Portland cement shall be used instead of Portland cement. When high-early-strength cement is used, concreting operations shall not be carried on if the atmospheric temperature is below or may be expected to drop below 50° F., except upon written authorization from the engineer. If the contractor, in order to facilitate his own operations, chooses to use high-early-strength cement in portions of work, other than those where its use is required, written permission must be obtained from the engineer.

Bags of cement in which, for any reason, the cement has become partially set, or which contain lumps of caked cement, shall be rejected. Use of cement salvaged from discarded or used bags will not be permitted. A bag of cement shall weigh not less than ninety-four (94) pounds net and will be considered one (1) cubic foot.

The cement shall be emptied from the shipping package directly into the skip of the mixer, or transported to the mixer in closed,

separate compartments equipped with waterproof covers for each batch, or under certain conditions may be transported by placing the unopened shipping packages upon the batch aggregates in trucks. The last-mentioned method will be permitted only upon condition that:

(a) Cement does not acquire moisture or dampness from aggregates during transportation.

(b) Tarpaulins are available for protection in case of wet weather.

(c) Shipping packages are emptied onto the aggregates of only those two trucks which have arrived within five hundred (500) feet of charging position at the mixer. In no case shall this period exceed forty-five (45) minutes prior to the charging of the mixer.

Natural cement may be used with Portland cement at or between a minimum ratio of one bag of natural cement to seven bags of Portland cement, and a maximum ratio of one bag of natural cement to four bags of Portland cement. An 85-pound bag of natural cement will be accepted for replacing a 94-pound bag of Portland cement. Natural cement shall conform with the requirements of A. S. T. M. Designation C-10, except that the use of a grinding aid will be mandatory. The natural cement shall be made water-repellent by the use of grinding aid composed of one-tenth (0.1) percent to two-tenths (0.2) percent paraffin in a carrier of oil or petroleum distillate not to exceed eight-tenths (0.8) percent by weight. In lieu thereof, the manufacturer may use from one-tenth (0.1) percent to two-tenths (0.2) percent tallow or fatty acid. A material known commercially as Darex AEA may be used in the natural cement in amounts from one-tenth (0.1) to thirty-five hundredths (0.35) percent. Other grinding aids or air-entrainment agents may be used upon approval of the engineer. Natural cement shall be blended with standard Portland cement that contains no admixtures for air-entrainment.

Bulk cement may be used, provided the manner and method of handling is approved by the engineer. Measurement of bulk cement shall be by weight. The scales for weighing bulk cement shall be of the springless dial type and shall be suitable for supporting the hopper. The accuracy of the scales shall be within a range of error of not over one-half ($\frac{1}{2}$) of one (1) percent of all loads. The batching equipment shall include a screen of such size and construction in the loading chute as will insure against the presence of burlap, paper, or other foreign materials in cement, and a canvas "boot" or other similar device which will prevent wastage or loss from air currents. This screen shall be cleaned at least once daily; more frequently if conditions justify. The equipment for handling bulk cement shall be so designed and constructed that no cement shall be wasted in transferring it from the cement bin to the mixer.

During transportation of bulk cement from the proportioning plant to the mixer, the cement shall be kept in a weatherproof compartment in the batch trucks, separate from the aggregates, or be placed between coarse and fine aggregates. In the latter case, a satisfactory

canvas cover or similar material shall be provided to cover the batch compartment to prevent loss. The cement shall not become so damp from the water in the aggregates to cause it to stick and cake to the sides or bottom of the batch truck aggregate compartment. When the cement is in contact with the aggregate, it shall not remain more than forty-five (45) minutes before being deposited into the mixer.

501-2.5 PREMOULDED JOINT MATERIAL. Premoulded joint material for expansion joints shall meet the requirements of one of the following A. A. S. H. O. Specifications: M-58, M-59, or M-90.

501-2.6 JOINT FILLER. The filler for joints shall meet the requirements of Item P-605, or shall be an asphalt cement meeting the requirements of A. A. S. H. O. Specification M-20 with 50-60 penetration used in the southern States, and 85-100 penetration used in the northern States. Where tar is available, it may be used but shall meet the requirements of A. A. S. H. O. Specification M-52, and be a heavy grade similar to RT-12.

501-2.7 STEEL REINFORCEMENT. Reinforcing may consist of either welded wire fabric or bar mats. Welded wire fabric shall meet the requirements of A. A. S. H. O. Specification M-55. Bar mats shall meet the requirements of A. A. S. H. O. Specification M-54, with the following specific requirements:

(a) All bars shall be intermediate grade billet steel, meeting A. A. S. H. O. Specification M-31.

(b) Longitudinal and transverse bars shall be connected at all marginal intersections and at least every alternate interior intersection, either by welding or by means of approved clips.

(c) If mats are fabricated by welding, plain bars may be used; if fabricated by means of clips, bars larger than $\frac{1}{4}$ -inch diameter shall be deformed bars.

501-2.8 DOWEL AND TIE BARS. Dowel and tie bars shall conform to the following specifications:

(a) Billet steel shall conform to A. A. S. H. O. Specification M-31.

(b) Rail steel shall conform to A. A. S. H. O. Specification M-42.

(c) Axle steel shall conform to A. A. S. H. O. Specification M-53.

The bars shall be free from flattening or burring of ends. If necessary, the ends of the bars shall be ground to remove the burrs resulting from shearing.

(d) Dowel and tie bars shall be of the size, type, and number shown on the plans, and shall be installed in such manner and locations as are indicated.

501-2.9 WATER. The water used in concrete shall be clean, clear, and free from injurious amounts of sewage, oil, acid, strong alkalis or vegetable matter, and also shall be free from clay and loam. If the water is of questionable quality, it shall be tested in accordance with A. A. S. H. O. Method T-26.

501-2.10 MATERIAL ADDED FOR WORKABILITY. The use of any material added to the mix to improve workability which, in

the opinion of the engineer, may have an injurious effect on the strength, density, and durability of the concrete will not be permitted. Before approval of any material, the contractor will be required to submit the results of complete chemical and sieve analyses made by an acceptable testing laboratory. Subsequent tests will be made of samples taken by the engineer from the supply of the material being used on the work to determine whether it is uniform in quality with that approved.

The material added shall be pozzuolanic, cementitious, or silicious. It shall not contain effective early-heat-producing elements or compounds, such as those contained in Portland cement, nor shall its use result in a material increase in the free-lime content of the concrete. It shall also be in conformity with the following requirements:

Free moisture—A total of not more than three (3) percent by weight.

Passing No. 30 mesh sieve—Not less than one hundred (100) percent by weight.

Passing No. 200 mesh sieve—Not less than eighty-five (85) percent by weight.

CONSTRUCTION METHODS

501-3.1 EQUIPMENT. All equipment necessary for the proper preparation of the subgrade, batching, and mixing of the concrete, the laying, finishing, and curing of the pavement, shall be on the project in first-class working condition, and be inspected and approved by the engineer before concreting begins.

501-3.2 CONDITIONING OF UNDERLYING COURSE. Ruts or depressions caused by hauling or usage of other equipment shall be filled as they develop with suitable material (not with concrete or concrete aggregates) and thoroughly compacted by rolling. A multiple pin templet weighing not less than 1,000 pounds (per 20-foot machine) or other approved templet, shall be provided and operated on the forms immediately in advance of the placing of the concrete. If the mixer is operated upon the grade, the templet shall be operated between the mixer and the finishing machine; in any case, it shall be propelled only by hand and not attached to mixer, tractor, or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying course. The adjustment and operation of the templet shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed, and if the grade is found to be below the true elevation the depressions shall be filled with approved material and thoroughly compacted to the proper cross section by rolling or tamping with a hand tamp.

The templet shall be maintained in accurate adjustment at all times by the contractor, and should be checked daily by the engineer or inspector.

The work described under the foregoing paragraphs does not contemplate a regular subgrading operation, but rather a final accurate check of the underlying course.

501-3.3 FORMS AND FORM SETTING. The side forms shall be of steel, of an approved section, shall be straight and of a depth equal to the thickness of the pavement at the edge. The base of the forms shall have a width equal to the depth up to and including an eight (8) inch form. When forms of a greater depth are required, the base shall be at least eight (8) inches.

All forms shall be set with exactness to the required grade and alignment, and be supported on thoroughly compacted material for their entire length during the entire operation of placing and finishing of concrete. They shall not at any time show a variation of more than one-eighth ($\frac{1}{8}$) inch in a ten (10) foot length from the true plane of top of forms. In the setting of side forms they shall be tested for grade and smoothness by the contractor, using a ten (10) foot straightedge, and variations from the above requirements shall be eliminated by the resetting of forms. Shimming with loose earth, pebbles, etc., will not be permitted. If a form does not have satisfactory bearing for its full length, it shall be removed, the bearing area of subgrade reshaped and compacted, and the form replaced. The use of bent or damaged side forms shall not be permitted. All forms shall be cleaned and oiled each time they are used. The alignment and grade of all forms set shall be approved before and immediately prior to the placing of any material against them, and shall not be removed until twelve (12) hours after the concrete has been placed. During the construction when the temperature is below 50° F., the forms shall not be removed in less than thirty (30) hours. A mechanical form tamper will be required. It shall be a self-powered type that rides on the forms and tamps the material under the forms simultaneously under both sides by digging action.

The contractor shall set and maintain sufficient forms, and shall otherwise so conduct his operations that the final minor corrections and compaction of grade, together with checking and approval of forms, will not in any way interfere with operations at the concreting site. While the amount of completed and accepted forms required in advance of the paving operation will vary with different organization and equipment, this amount shall in no case be less than 500 feet (each side).

Adjacent lanes may be used in lieu of forms for supporting finishing equipment provided that proper protection is afforded the concrete of the adjacent lanes from damage, and further provided that the surface of the concrete carrying the finishing equipment does not vary more than one-eighth ($\frac{1}{8}$) inch in a ten (10) foot length. Adjacent lanes in lieu of forms may not be used until the concrete is at least seven (7) days old. Flanged wheels of the finishing equipment shall not be operated on the concrete surface. The inside edge

of supporting wheels of the finishing machine shall not operate closer than four (4) inches to the edge of the concrete lane.

501-3.4 HANDLING, STORAGE, AND PROTECTION OF MATERIALS. Batching of aggregates from bins from which the water has not been thoroughly drained will not be permitted. Aggregates, if wet, shall be stocked-piled for a period of at least twenty-four (24) hours prior to batching so that moisture content will be as uniform as possible. Aggregates shall be so handled that the moisture content is reasonably uniform and does not change appreciably from batch to batch or from hour to hour. The stock piles of aggregates shall be built up in layers not to exceed three (3) feet in height, and each layer shall be completely in place before beginning the next. Coning or building up of stock piles by depositing materials in one place will not be permitted.

Each stock pile shall be placed on concrete, sheet metal, wood plank platforms, or other satisfactory foundations, and so arranged that the different aggregates do not become mixed. Adjacent stock piles shall be separated by bulkheads to prevent intermixing of the stock piles.

Mixing stone and gravel, or fine aggregates from different sources in one storage pile, or alternating batches of different aggregates, will not be permitted.

501-3.5 PROPORTIONS. The weights of fine and coarse aggregate, and the quantity of water per bag of cement, shall be determined by the engineer from the weights given in the tables, with the net amount of water (including free water in the aggregates) as shown, and the range in slump as stated.

CLASS A PAVING CONCRETE

(For use where severe climatic conditions prevail)

Type of coarse aggregate	Minimum cement content, per cu. yd. of concrete	Maximum net water content, gals. per bag	Weights in pounds of dry aggregate, per bag of cement			Slump range, inches
			Fine aggregate	Coarse aggregate	Total	

STANDARD METHOD OF PLACEMENT

Gravel.....	6 bags.....	5½.....	170	367	537	1½-2½
Crushed stone.....	6 bags.....	5¾.....	195	341	536	1½-2½
Slag.....	6 bags.....	5¾.....	205	287	492	1½-2½

VIBRATORY METHOD OF PLACEMENT

Gravel.....	5.8 bags.....	5½.....	169	394	563	1-1½
Crushed stone.....	5.8 bags.....	5¾.....	195	366	561	1-1½
Slag.....	5.8 bags.....	5¾.....	205	309	514	1-1½

CLASS B PAVING CONCRETE

(For use where moderate climatic conditions prevail)

Type of coarse aggregate	Minimum cement content, per cu. yd. of concrete	Maximum net water content, gals. per bag	Weights in pounds of dry aggregate, per bag of cement			Slump range, inches
			Fine aggregate	Coarse aggregate	Total	

STANDARD METHOD OF PLACEMENT

Gravel.....	5.5 bags.....	6.....	190	403	593	1½-2½
Crushed stone.....	5.5 bags.....	6¾.....	220	371	591	1½-2½
Slag.....	5.5 bags.....	6¾.....	230	316	546	1½-2½

VIBRATORY METHOD OF PLACEMENT

Gravel.....	5.3 bags.....	6.....	187	437	624	1-1½
Crushed stone.....	5.3 bags.....	6¾.....	216	406	622	1-1½
Slag.....	5.3 bags.....	6¾.....	226	344	570	1-1½

CLASS C PAVING CONCRETE

(For use where mild climatic conditions prevail)

Type of coarse aggregate	Minimum cement content, per cu. yd. of concrete	Maximum net water content, gals. per bag	Weights in pounds of dry aggregate, per bag of cement			Slump range, inches
			Fine aggregate	Coarse aggregate	Total	

STANDARD METHOD OF PLACEMENT

Gravel.....	5 bags.....	6½.....	220	443	663	1½-2½
Crushed stone.....	5 bags.....	6¾.....	250	411	661	1½-2½
Slag.....	5 bags.....	6¾.....	260	347	607	1½-2½

VIBRATORY METHOD OF PLACEMENT

Gravel.....	4.8 bags.....	6½.....	210	490	700	1-1½
Crushed stone.....	4.8 bags.....	6¾.....	243	456	699	1-1½
Slag.....	4.8 bags.....	6¾.....	253	388	641	1-1½

The proportions on the preceding pages are based on the use of well-graded aggregates. If it is found impossible with the aggregates selected to prepare concrete of the proper consistency without exceeding the maximum net water content specified, the total weight of aggregate shall be reduced by the engineer until concrete of the proper consistency is obtained without exceeding the maximum net

water content specified. However, the contractor shall not be compensated for any additional cement which may be required by reason of such adjustment.

The weights specified in the above tables were calculated for aggregates of the following bulk specific gravities: Natural sand and gravel, 2.62; crushed stone, 2.65; slag, 2.30. For aggregates of specific gravities differing more than plus or minus 0.02 from those given above, the weights given in the tables shall be corrected as indicated in paragraph (b). The quantities shown in the tables for Class A, B, and C concrete for cement and water shall control, and the weights of aggregates shall be varied to secure the proper yield based on absolute volumes.

At any time during the construction period, the relative weights of fine and coarse aggregates, as determined from the preceding tables, may be varied slightly in order to insure the use of the least amount of fine aggregate which will produce workable concrete within the specified slump range. When separated sizes of coarse aggregates are used, the ratio of either size to total coarse aggregate may be varied within the range of forty (40) to sixty (60) percent by weight to secure the most dense and uniform gradation of the combined material.

(a) For batch weights, the weights arrived at as described above shall be corrected to compensate for moisture contained in the aggregate at the time of use.

(b) If, during the progress of the work, the specific gravity of one or both of the aggregates changes, the batch weight shall be adjusted to conform to the new specific gravity by multiplying the weight given in the table by the specific gravity of the aggregates used and dividing by the corresponding specific gravity used in calculating the weight given in the table.

(c) Yield test, made in accordance with specification A. S. T. M. Designation C-138, shall be made by the engineer for the purpose of determining the cement content per cubic yard of concrete. If at any time such cement content is found to be less than that specified per cubic yard, the batch weights shall be reduced until the amount of cement per cubic yard of concrete conforms to the requirements.

The net mixing water shall be adjusted for the moisture contained in the aggregates, and for the moisture which they will absorb, in order to determine the amount of water to be added at the mixer. The absorption of the fine and coarse aggregates shall be determined by A. A. S. H. O. Methods T-84 and T-85.

When air-entraining Portland cement is used there will be a bulking of the mortar of the concrete due to the amount of entrained air. To keep the cement factor specified at the correct amount, the weight of the fine aggregate shall be reduced, as directed by the engineer. The reduction in the fine aggregate shall be determined by yield tests as specified. Under average conditions the reduction of the sand should be about three (3) percent of the total weight of the fine and coarse

aggregate. The air content of the concrete shall be between three (3) and six (6) percent by volume, which can be determined by weighing.

501-3.6 MEASUREMENT OF AGGREGATES. Where sack cement is used, the quantities of aggregate for each batch shall be exactly sufficient for one or more sacks of cement; no batch requiring a fraction of a sack of cement will be permitted. All measurement shall be by weight, upon approved weighing scales, and shall be such as will insure separate and uniform proportions. Scales shall be of either beam or springless dial type, and shall be suitable for supporting the hopper or hoppers. They shall be set accurately in substantial mountings which will insure a permanent spacing of the knife edges under all conditions of loading and use. They shall be so designed and maintained that they will at all times be accurate to within one-half ($\frac{1}{2}$) of one (1) percent throughout the entire weight range. Clearance shall be provided between the scale parts and the hopper or the bin structure to prevent displacement of the scale parts due to vibrations, accumulation, or any other cause. The value of the minimum graduations on any scale shall not be greater than five (5) pounds. The weighing beam or dial shall be so placed that it will be in full view of the operator during the operation of the gate which delivers the material to the hopper. Scales shall be protected from air currents that may affect the accuracy of weighing.

Separate hoppers shall be provided for weighing fine and coarse aggregate, shall be of suitable size and tight enough to hold the aggregate without leakage, and shall be supported entirely upon the scales. Suitable provision shall be made for removal of overload from the hopper by the operator while he operates the bin gates.

The contractor shall maintain at the batching plant at all times a set of accurate platform scales of at least 500 pounds capacity for the use of the engineer or inspector in making weight tests of aggregates; also ten fifty (50) pound standard test weights for testing weighing equipment.

The volume of concrete mixed per batch shall not exceed the manufacturer's guaranteed capacity of the mixer, as specified in the Concrete Mixer Standards adopted by the Mixer Manufacturer's Bureau and approved by the Associated General Contractors of America.

When the aggregates are transported by industrial railway, or delivered to the mixer in trucks, each batch shall be in a separate compartment of the capacity required by the engineer. Subdivided truck bodies shall be approved by the engineer before they may be used, and the cement compartment shall be provided with an approved waterproof cover. All trucks, truck bodies, bulkheads, current compartments, and other equipment or accessories used in the proportioning and transportation to the mixer of concrete materials shall be so designed and operated as to insure the charging of the mixer, batch by batch, with the proper amounts of each material without over-spillage, intermixing of batches, or wastage. Any units which, in the opinion of the engineer, do not operate satisfactorily shall be removed from the project until properly rebuilt and corrected.

501-3.7 CONSISTENCY. When subjected to the slump test for consistency, made in accordance with the Tentative Method of Test for Consistency of Portland Cement Concrete, A. S. T. M. Designation C-143, concrete to be finished by ordinary methods shall have a slump of not greater than $2\frac{1}{2}$ inches nor less than $1\frac{1}{2}$ inches. Where vibratory finishing methods are used, the concrete shall have a slump of not greater than $1\frac{1}{2}$ inches nor less than 1 inch. The water shall be regulated and gauged accurately, and shall be discharged into the drum as specified. The quantity of mixing water shall be determined by the engineer in accordance with Section 3.5, and shall not be varied without his consent.

501-3.8 MIXING. Mixing shall conform to one of the two methods described herewith:

(a) *Paving Mixture at Job Site.* The mixing machine used shall be of an approved type known as a batch mixer, and of a design having a suitable device attached for automatically measuring the proper amount of water accurate to one (1) percent, and for automatically timing each batch of concrete so that all materials will be mixed together for the minimum time required. Such device shall be easily regulated and controlled to meet the variable conditions encountered. If the timing device becomes broken or fails to operate, the contractor will be permitted to continue for the balance of the day without the timing device while the same is being repaired, providing that each batch of concrete is mixed two (2) minutes.

The mixing time for each batch shall be one (1) minute, and the measuring of this period shall begin after all the materials are in the drum. During this mixing period the drum shall revolve at the speed for which the mixer is designed, but shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute.

No materials for a batch of concrete shall be placed in the drum of the mixer until all of the previous batch has been discharged therefrom. The discharge of water into the drum shall commence with the flow of the aggregates, but shall not be started before the entrance into the drum of part of the aggregates. The discharge of all of the mixing water for any batch shall be completed within ten (10) seconds after all of the aggregates are in the drum. The inside of the drum shall be kept free from hardened concrete.

The use of mixers having a chute delivery will not be permitted except as approved. In all such cases the arrangement of chutes, baffle plates, etc., shall be such as will insure the placing of fresh concrete without segregation.

(b) *Ready Mixed.* Ready-mixed concrete may be centrally mixed, shrink-mixed, or transit-mixed concrete delivered at the work ready for use.

Central mixing is the process of suitably mixing concrete in a stationary mixer, meeting the requirements of Section 3.8a, and continuing the mixing at agitation speed in a truck mixer or truck agitator to prevent segregation while in transit to the destination.

Shrink-mixing is the process of completing in a truck mixer while in transit to destination, the mixing of concrete which has been partially mixed in a stationary mixer at least thirty (30) seconds.

Transit mixing is the process of combining the aggregate, cement, and water into a thoroughly mixed and uniform mass of concrete in a truck mixer.

The truck mixer shall consist of a closed watertight revolving drum, suitably mounted and fitted with adequate blades, or a watertight container equipped with a removable cover, suitably mounted and fitted with adequate revolving blades. Truck mixers shall be capable of combining aggregates, cement, and water into a thoroughly mixed and uniform mass of concrete, and of discharging the concrete without segregation. The truck agitator shall consist of a closed watertight revolving drum or a watertight container, equipped with a removable cover, suitably mounted and fitted with adequate revolving blades. Truck agitators shall be capable of transporting and discharging concrete without segregation.

Attached to each truck mixer and truck agitator there shall be a metal plate, on which is stated the manufacturer's capacities in terms of volume of mixed concrete for the various uses to which the equipment is applicable, and the manufacturer's stated speed of rotation for both mixing and agitation.

For revolving drum-type mixers the mixing speed shall not be less than four (4) r. p. m. of the drum, nor greater than that which will produce a peripheral velocity of more than 225 feet per minute. For revolving blade-type mixers, the mixer speed shall be not less than six (6) nor more than sixteen (16) r. p. m. of the mixing blades. Agitation speed shall be not less than two (2) nor more than six (6) r. p. m. of the drum or mixing blades.

The mixer shall be equipped with a locking device which will automatically prevent the discharging of the mixer prior to receiving the required number of drum or blade revolutions, or a counter mounted on the mixer permitting the reading of the count at the proportioning plant and at the destination.

A water-measuring device, capable of accurately measuring the water to one (1) percent, shall be mounted on the truck mixer or located at the point of charging the mixing water. It shall permit ready access and ready determination of the amount of water used. Wash water shall not be used in any concrete mix.

In general, for transit mix concrete, the water and cement shall be charged into the mixer at the proportioning plant with the fine and coarse aggregate. If, for any reason, the proper control of the consistency or mixing of the concrete is not obtained when the water and cement are charged at the proportioning plant, the time of charging the cement and water shall be as directed by the engineer. In no case shall the cement be added until all the mixing water is in the mixer.

Immediately after all ingredients are in the mixer, mixing shall be started and continued until discharged. In the case of truck mixers

into which the fine and coarse aggregates are charged simultaneously, or which mix during the charging operation for transit mix, not less than fifty (50) revolutions of the drum or blades at mixing speed shall be required after all of the ingredients, including water, are in the mixer. In the case of truck mixers, into which the fine and coarse aggregates are charged separately, and which do not mix during the charging operation for transit mix, not less than sixty (60) revolutions of the drum or blades at mixing speeds shall be required after all of the ingredients, including water, are in the mixer. For shrink-mix, not less than forty (40) revolutions of the truck mixer drum or blades shall be required. For both transit mix and shrink-mix, not more than one hundred and fifty (150) revolutions of the drum or blades shall be at the rate of rotation stated by the manufacturer as mixing speed. Additional mixing shall be at a slower speed, as stated by the manufacturer, as agitation speed.

Concrete shall be delivered to the work and discharged from the mixer or agitator within a period of one (1) hour after all the ingredients are in the mixer or agitator.

Each load of ready-mixed concrete shall be accompanied by a plant ticket completely filled out. Upon arrival at the job, the driver shall present one copy of the plant ticket to the engineer or inspector.

Where high-early-strength cement is used, the maximum time in the mixer may be reduced by the engineer.

(c) *General.* In the transporting of proportioned aggregates, or of ready-mixed concrete to the project, the gross weight which will be permitted on the subgrade shall not exceed 550 pounds per inch of width of tire, except by written permission of the engineer. The gross weight shall include the weight of the vehicle plus the load thereon.

Retempering of concrete which has partially hardened (i. e., remixing with or without the addition of water) will not be permitted.

501-3.9 PLACING AND FINISHING CONCRETE. The provisions of this section are general and pertain to placing and finishing concrete by any of the methods as provided hereafter. Unless otherwise shown on the drawings or designated by the engineer, the maximum width of the pavement strip shall be twenty-five (25) feet and the minimum width ten (10) feet. Unless otherwise called for on the plans, the method of placing and finishing may be either "Ordinary Finishing" or "Vibratory Finishing."

The underlying course shall be sprinkled at such times, and in such manner as directed by the engineer, so that it will be in a thoroughly moistened condition (but not muddy) when the concrete is deposited thereon. If deemed necessary, the grade shall be sprinkled the evening prior to the placing of concrete. Extra care shall be exercised after moistening to maintain and protect a correct and unmarked grade surface.

The mixer shall not be operated on a completed pavement lane at any time unless specifically authorized by the engineer, and only when the concrete is at least ten (10) days old. When this operation is per-

mitted, any cement or mortar shall be removed immediately from the pavement surface with spraying and scrubbing if necessary.

The concrete shall be so deposited and spread that any segregation will be corrected, and a uniform layer of concrete produced whose thickness is approximately one (1) inch greater than that required for the finished pavement. Rakes shall not be used for handling concrete.

In order to prevent the introduction into the concrete of earth and other foreign materials, the "muckers," or men whose duties require them to work in the concrete, shall, in general, confine their movements to the area already covered with fresh concrete. Whenever it becomes necessary for these men to step out of the concrete, their footwear shall be washed or otherwise thoroughly cleansed before returning to the concrete. Repeated carelessness in regard to this detail will be deemed sufficient cause for removing and replacing such workmen.

During the operation of striking off the concrete, a uniform ridge of concrete at least three (3) inches in depth shall be maintained ahead of the strike-off screed for its entire length.

Except when making a construction joint, the finishing machine shall at no time be operated beyond that point where the above-described surplus can be maintained in front of the strike-off screed.

After the first operation of the finishing machine, additional concrete shall be added to all low places and honeycombed spots and the concrete rescreeded. In any rescreeding, a uniform head of concrete shall be maintained ahead of the strike-off for its entire length. Honeycombed spots shall not be eliminated by tamping or grouting.

The concrete adjacent to transverse joints shall be thoroughly compacted by means of an approved internal vibrator. The internal vibrators shall be of pneumatic, gas-driven, or electric type, and shall operate at a frequency of not less than 3,200 pulsations per minute.

In conjunction with the placing and spreading, the concrete shall be thoroughly spaded and vibrated along the forms, bulkheads, and joints.

After the final pass of the finishing machine, the placing of all joints longitudinal and transverse, and the concrete has started to dry, the surface of the pavement shall be finished with an approved longitudinal float. The float may be operated either manually or by mechanical means. The float may be either of wood or metal, shall be straight and smooth, and light in weight so as not to displace or sink into the concrete surface. To be effective, the float shall be at least twelve (12) inches wide and ten (10) feet long. When manually operated the float shall be moved from edge to edge with a wiping motion and advanced several feet. The succeeding trip shall overlap the previous trip. A light smoothing lute at least ten (10) feet long may be used when approved by the engineer.

The surface of the pavement shall be tested by the contractor, before the final belting, with an approved standard straightedge sixteen (16) feet in length. Irregularities so detected shall be corrected immediately. Special attention must be given to the concrete

adjacent to transverse joints to insure that the edges thereof are not above the grade specified, or the adjacent concrete below grade. All depressions or projections discovered shall be corrected before any initial set has developed in the concrete.

After the concrete has been brought to the required grade, contour, and smoothness, it shall be finished by means of a finishing belt. The finishing belt shall be not less than eight (8) nor more than twelve (12) inches in width, and at least two (2) feet longer than the width of the pavement section to be finished. The belt of canvass composition, three-ply burlap construction, or approved alternate, shall be worked with a combined longitudinal and transverse motion until all surface irregularities are eliminated. The finishing belt may be operated either by hand or mechanically. The belt shall be kept clean and free from hardened concrete.

As soon as the concrete is sufficiently hardened, the edges of the pavement, the longitudinal joints, the construction, dummy, and expansion joints shall be carefully finished with an edging tool having a radius of at least one-quarter ($\frac{1}{4}$) inch. The tools, the special accessories for cutting impressed joints, and the methods of workmanship shall be such as will produce a joint whose edges are of the same quality of concrete as the other portions of the pavement. Methods and workmanship which make use of excess mortar or grout in this area shall be eliminated. Unnecessary tool marks shall be eliminated during construction, and the edges left smooth and true to line.

Whenever the placing of the concrete is stopped or suspended for any reason, for a period of thirty (30) minutes or longer, a suitable bulkhead shall be placed so as to produce a vertical joint which is perpendicular to the centerline and to the surface of the pavement. If an emergency stop occurs within eight (8) feet after a contraction or an expansion joint has been placed, the concrete shall be removed back to the previously installed joint. When a construction joint is placed it shall be dowelled or not, as prescribed on the plans. When the placing of the concrete is resumed, the bulkhead shall be removed and new concrete placed and vibrated evenly and solidly against the face of the previously deposited concrete. Any concrete in excess of the amount needed to complete a given section, or that has been deposited outside the forms, shall not be used in the work.

After the removal of the forms, all honeycombed edges shall be immediately filled with one to two mortar.

501-3.10 HAND FINISHING. Hand finishing will be permitted on variable width sections of the pavement and other places where the use of the finishing machine would be impracticable. Hand finishing shall be accomplished by means of a hand-operated strike-off templet of either steel or steel-shod wood construction.

This striking templet shall be operated forward with a combined longitudinal and transverse motion, and shall be so manipulated that neither end will be raised off the side forms. A similar templet shall

be used for tamping the concrete. All templets shall have the proper crown.

All other details of the finishing operations shall be as provided under Section 3.9.

501-3.11 ORDINARY FINISHING. The concrete shall be compacted and finished by a mechanical, self-propelled spreading and finishing machine of approved type, having two independently operated screeds. If a machine possessing only one screed is approved, the screed shall be not less than eighteen (18) inches in width, and shall be equipped with compensating springs to minimize the effect of the momentum of the screed on the side forms. The number of driving wheels, the weight of the machine, and the power of the motor shall be so coordinated as to prevent slippage. The top of the forms and the surface of the finishing machine wheels shall be kept free of concrete or dirt.

The machine shall at all times be in first-class mechanical condition, and shall be capable of compacting and finishing the concrete as herein described. Any machine which causes displacement of the side forms from the line or grade to which they have been properly set, or causes undue delay due to mechanical difficulties, shall be removed from the work and replaced by a machine meeting these specifications.

The finishing machine shall be operated over each section of pavement two or more times and at such intervals as will produce the desired results. Generally, two passes of the finishing machine are considered the maximum desirable.

All other details of the finishing operations shall be as provided under Section 3.9.

501-3.12 VIBRATORY FINISHING. When specified, the concrete shall be vibrated, compacted, and finished by a vibratory finishing machine. The vibratory machine shall meet the requirements for ordinary finishing, and shall be one of the following types:

(a) This type of external vibratory finishing machine shall have two independently operated screeds. The front screed shall be equipped with vibratory units with a frequency of not less than 3,500 pulsations per minute. There shall be not less than one vibratory unit for each eight (8) foot length, or portion thereof, of vibratory screed surface. The front screed shall be not less than twelve (12) inches wide, and shall be equipped with a "bull nose" front edge built on a radius of not less than two (2) inches. This type of vibratory finishing machine shall be operated in such a manner that each section of pavement will receive at least one vibratory pass, but not more than two passes, unless otherwise directed.

(b) This type of external vibratory finishing machine shall be equipped with an independently operated vibratory "pan" (or pans) and two independently operated screeds. The "pan" shall be mounted in a manner that will not permit it to come in contact with the forms, and will permit vibration of the full width of the lane simultaneously. There shall be not less than one vibratory unit for each six (6) foot

length, or portion thereof, of vibrating pan surface. The vibratory units on any individual pan shall be synchronized and have a frequency of not less than 3,500 pulsations per minute. The front screed shall be capable of operating in a position that will strike off the concrete at a sufficient height above the top of the forms to allow for proper compaction with the vibrating pan. This type of vibratory finishing machine shall be operated in such a manner that each section of pavement will receive at least one vibratory pass but not more than two passes, unless otherwise directed.

(c) Other vibratory finishing equipment may be used on a trial basis upon submission of evidence, satisfactory to the engineer, of its successful performance in placing and finishing concrete of the same quality and consistency as required under this specification for concrete for vibration.

Failure of equipment permitted on trial to perform in a satisfactory manner, either mechanically or in its ability to place concrete of the consistency required for vibration, shall be cause for its removal from the work and replacement by vibratory finishing equipment of an approved type.

The vibratory finishing machines shall be operated in the same manner as specified for ordinary finishing.

All other details of the finishing operations shall be as provided under Section 3.9.

501-3.13 PRELIMINARY CURING. The surface of the concrete shall be covered with wet burlap, wet cotton mats, wet jute felt mats, or paper as soon as the concrete has hardened sufficiently to prevent excessive marring of the surface or adherence thereto.

Where burlap is used it shall be placed in strips two (2) feet longer than the width of the pavement lane and applied so as to overlap at least four (4) inches. The burlap shall be placed on the concrete in double thickness. Each thickness of burlap shall weigh, when dry, at least seven (7) ounces per square yard. The burlap shall at all times be kept in a thoroughly moistened condition until it is removed. The burlap shall remain on the concrete for at least twelve (12) hours and then be removed as directed. Burlap which has been used for any purpose other than the curing of concrete shall not be used.

Where cotton mats are used they shall meet the requirements listed under Section 3.14 (a) and shall be used as prescribed in that section.

Where jute felt mats are used they shall meet the requirements listed under Section 3.14 (a) and shall be used as prescribed in that section.

Where paper is used it shall meet the requirements listed under Section 3.14 (b) and shall be used as prescribed in that section.

After the completion of the preliminary curing the burlap shall be removed in such a manner that not more than sixty (60) linear feet of pavement is exposed at one time, and followed at once by application of the subsequent curing agent.

501-3.14 CURING. The curing of the concrete shall be accomplished by one of the following methods, as hereinafter noted.

The curing method selected when tested in accordance with the method prescribed in the Tentative Method of Test for Efficiency of Materials for Curing Concrete, A. S. T. M. Designation C-156, shall retain within the specimen at the end of seven (7) days at least ninety (90) percent of the original water used in the mix.

(a) *Water Curing.* As soon as the forms have been removed and all honeycomb corrected, earth shall be banked against the edges of the pavement. After the removal of the burlap, but in no case later than 10 a. m. of the day following the placing of the concrete, the curing of the concrete shall be continued by one of the water-curing methods hereinafter described.

Water curing may be accomplished by the use of one of the following methods by covering the concrete with:

Cotton Mats.

Jute Felt Mats.

Cotton mats shall be saturated immediately before placing, and shall be kept saturated with water for the duration of the curing period. The mats shall be constructed with at least six (6) ounces of burlap or Osnaburg, and shall be at least twelve (12) feet wide and equal in length to the width of the pavement strip plus two (2) feet.

Jute felt mats shall be saturated immediately before placing, and shall be kept saturated with water for the duration of the curing period. The mats shall be constructed with at least eight and one-half (8½) ounces of jute filler between two layers of six (6) ounce burlap, and shall be at least six (6) feet wide and equal in length to the width of the pavement strip plus two (2) feet.

(b) *Paper Curing.* This method shall consist of a covering of the pavement surface with impermeable waterproof paper blankets for a period as designated.

For the preliminary curing, the blankets shall be placed as soon as practicable after final finishing without marring the surface, yet early enough to prevent undue loss of moisture.

At any other time, the surface of the pavement shall be thoroughly drenched before being covered with the paper-curing agent.

Paper to be used for curing concrete shall be of a type and quality approved by the engineer. It shall be reinforced sufficiently to permit its use under the conditions existing on paving work without being torn or otherwise rendered unfit for the purpose during the curing period. The element used in reinforcing the paper must be completely embedded in the asphalt, leaving no voids or white spots when the sheet is opened for inspection by the engineer. If sisal fibres are the reinforcing agent, approximately 1,400 linear feet per square yard shall be embedded in each sheet. If jute is used, it shall be six (6) pound stock. When jute or cotton yarns are employed for reinforcing, they shall cross each other at approximately

right angles, and be spaced not more than one-half ($\frac{1}{2}$) inch apart each way.

The blankets shall not be less than twenty (20) nor more than seventy-five (75) feet in length, and shall be of a width which, when in place, will extend not less than twelve (12) inches beyond each edge of the pavement, or supplemental stringer sheets at least eighteen (18) inches wide shall be placed along the edges of the pavement under the blankets. Unless the paper has been pretreated to resist such action, an eight (8) inch pleat to allow for shrinkage of the paper shall be placed near one edge of the pavement. All joints in the blankets shall be securely cemented together in such a manner as to provide seams with a minimum lap of four (4) inches, producing a waterproof joint, using an asphalt cement having a melting point of approximately 180° F.

The blankets shall be placed as soon as practicable after the finishing operations in such a manner that the surface of the concrete will not be marred. They shall be unrolled from poles or timbers. The blankets shall be securely weighted down either by placing a row of earth on the edges of the blankets just inside the forms, or by an approved method. When placed, the adjoining blankets shall overlap at least twelve (12) inches. This lap shall also be securely weighted down to form a closed joint. Upon removal of the forms, the supplemental stringer sheets shall be pulled out and carried down to the bottom of the pavement and be secured with a continuous bank of earth. The contractor may, if he so elects, blade a windrow of earth completely covering the edges of the pavement, provided that it is kept in a moist condition for the curing period.

In the event that hair-checking develops before the paper can be applied, the procedure as set forth above shall be modified in that initial curing with wet burlap shall be performed before the paper covering is placed.

At the end of each four (4) day curing period, the blankets shall be checked over and all holes or tears must be repaired by cementing patches over them. When the blankets are no longer serviceable as a single unit, the engineer may select from the rejected blankets those which, in his opinion, will serve for further applications, provided that two (2) blankets are used as a single unit. However, the doubled unit may be rejected when, in the opinion of the engineer, it no longer provides an airtight cover.

The duration of the curing period under this method shall be as provided under Section 3.15.

501-3.15 DURATION OF CURING. The total period for water and paper curing, as described above, shall be continued for four (4) days including the preliminary water curing.

Where high-early-strength Portland cement is used, the period of curing may be reduced to three (3) days.

501-3.16 DEPOSITING AND PROTECTING CONCRETE DURING COLD WEATHER. Concrete shall not be placed when

the temperature of the air, aggregates, or water is 40° F. or below, except when directed by the engineer. If placed under these conditions, the water or aggregates, or both, shall be heated, the aggregates preferably by steam, so that the concrete, immediately after placing in the forms, shall have a temperature of between 65° F. and 85° F. The heating of the aggregate shall be done in a uniform manner which will preclude burning or otherwise damaging same. In no case shall concrete be deposited upon a frozen course.

Adequate precautions shall be taken for such protection of all concrete after it is placed in position as will prevent the temperature of the deposited concrete falling below 50° F. until the required curing period has elapsed. A sufficient supply of straw, hay, or other materials suitable for covering or protecting the concrete shall be provided on the work and spread to a depth as directed to prevent freezing. Manure shall not be used as a protection for green concrete.

Any concrete showing injury or damage by freezing shall be removed and replaced at the expense of the contractor.

501-3.17 SPECIAL WINTER CONCRETE CONSTRUCTION. When so required by the plans or proposal, special winter construction methods conforming to the requirements of this section of the specifications shall be followed. The contractor shall prosecute the work promptly and continuously through the winter months until the project has been completed. All work shall be done in accordance with the provisions of the general specifications except as modified herewith.

(a) *Underlying Course.* The course upon which concrete is to be placed shall be so treated, protected, and prepared as will produce a satisfactory grade, properly shaped and compacted, and entirely free from frost when concrete is deposited.

(b) *Heating and Protection.* The heating of materials and the protection of the concrete shall be in accordance with the provisions of Section 3.16.

(c) *Curing.* Curing shall be performed as specified under Section 3.14, except that immediately after the burlap or cotton mats have been wet as specified in Section 3.13, the burlap or cotton mats shall be covered and kept covered with at least twelve (12) inches of straw until the required curing period has elapsed.

The above requirements for curing are minimum requirements only, and are deemed necessary because of uncertain and unexpected weather conditions. The protection requirements of Section 3.15 are in no way voided. The straw covering shall be kept in place for at least ten (10) days, or as directed.

501-3.18 TRANSVERSE CONSTRUCTION JOINTS. Transverse construction joints shall be built in accordance with the plans whenever necessary to suspend the work for a period of more than thirty (30) minutes. At the end of a day's work the joint shall be placed at a contraction or expansion joint. The joints shall be constructed perpendicular to both the centerline and the surface of the

pavement. In no case shall an emergency construction joint be allowed within eight (8) feet after placing a regular expansion or contraction joint. If the joint falls within this limit, the concrete shall be removed back to the previously installed joint.

501-3.19 TRANSVERSE CONTRACTION JOINTS. Transverse contraction joints shall be constructed in accordance with the plans and at designated intervals. Joints shall be true and straight and normal to the centerline and surface of the pavement. Variation of more than one-fourth ($\frac{1}{4}$) inch in ten (10) feet from a straight line will not be permitted. The joints shall be continuous for the full width of the pavement. Contraction joints shall be of the dummy-groove type.

The joint shall be so placed that its junction with the longitudinal joints will be a neat-fitting connection providing a complete separation of the slab for the entire depth of the joint.

No machine or method of operation that does not produce a joint meeting the requirements of variation of not more than one-fourth ($\frac{1}{4}$) inch in ten (10) feet will be permitted to continue in operation on the project.

501-3.20 TRANSVERSE EXPANSION JOINTS. (a) *Premolded Filler.* Expansion joints shall be of a premolded type conforming with these specifications and with the plans, and shall be spaced as directed. The joints shall form a continuous line for the full width and depth of the pavement strip.

The joints shall be installed at right angles to the centerline and perpendicular to the surface of the pavement. The joints shall be so installed and finished to insure complete separation of the slabs.

Where premolded expansion joints are used no section of the joint material shall be shorter than the width of pavement strip between longitudinal joints. The filler shall be placed one (1) inch below the surface. All concrete shall be cleaned off the top of the joint material. Before the pavement is opened to traffic this space shall be swept clean and filled with approved joint sealing material.

For premolded expansion joints which require a plate for added rigidity during installation, an oiled steel plate cut to the cross section of the pavement and slotted for the dowel bars or transfer-of-load devices shall be used to hold the premolded joint material in its proper position until the finishing machine has completed its operation.

All devices used for the installation of expansion joints shall be approved by the engineer. They shall be easily removable without disturbing the concrete and held in proper transverse and vertical alignment. Immediately after forms are removed, any concrete bridging the joint space at the ends shall be removed for the full width and depth of the joint.

(b) *Dowels.* When called for, expansion joints shall be equipped with dowels of the dimensions and at the spacing and location indicated on the plans. The dowels shall be firmly supported in place,

accurately aligned parallel to the subgrade and the centerline of the pavement, by means of a dowel assembly which will remain in the pavement and will insure that the dowels are not displaced during construction.

Other types of load transfer devices may be used on the approval of the engineer.

501-3.21 LONGITUDINAL JOINTS. (a) The longitudinal construction joints shall be constructed where and in the manner as shown on the plans.

(b) The longitudinal contraction joint when required shall be constructed with a dummy-groove joint in accordance with the detail drawings. Variation of more than one-fourth ($\frac{1}{4}$) inch in ten (10) feet from a straight line will not be permitted. The joint shall be so placed that the junction with the transverse joint will be a neat-fitting connection.

(c) The longitudinal expansion joint, when required, shall be constructed with premoulded type conforming to these specifications and with the plans, and shall be placed as directed. The material shall be of the proper thickness, depth, and length, and shall be installed in a neat and satisfactory manner.

501-3.22 FILLING OF JOINTS. Joint-filling operations shall not be started until after the final curing is completed. All joints which require filling shall be thoroughly cleaned, and any excess mortar or concrete cut out with chisels. Joints shall be filled only when completely dry. When asphalt is used, the joints shall be primed with a light asphalt cut-back. The filler used shall be material as specified in paragraph 2.6. The application temperature for average conditions shall be at 300° F. for asphalt filler and 225° F. for tar filler. The cleaning and filling shall be carefully done with proper equipment, and a neat workmanlike joint obtained free from excess and unsightly filler. The contractor shall "spot up" or refill all unsatisfactory joints before final acceptance.

Kettles for heating filler, which are not otherwise equipped with equivalent means of insulation, shall be provided with a swinging pan so interposed between the kettle and pavement as to provide a minimum of two (2) inches of air space between pan and pavement at all times. Suitable equipment shall be furnished for heating the filler material and so designed to prevent burning the filler either at the start or during the heating procedure.

501-3.23 REQUIREMENTS FOR THICKNESS. The thickness of concrete pavement may be determined by the measurement of cores cut at designated locations. The cutting of cores will be at the discretion of the engineer, and will not be at the expense of the contractor. The average thickness of concrete pavement shall be determined by prescribed sections as hereinafter specified.

The thickness of concrete at any point shall not be more than one-half ($\frac{1}{2}$) of an inch less than the specified thickness, nor shall the average thickness of the concrete be more than one-fourth ($\frac{1}{4}$) of an

inch less than the specified thickness. Deductions for deficiency in thickness are herewith tabulated:

Deficiency in thickness determined as described in this section	Proportional part of contract price allowed
0.00 inch to 0.25 inch	100 percent
0.26 inch to 0.50 inch	Ratio: $\frac{(\text{Actual Thickness})^2}{(\text{Specified Thickness})^2}$
Greater than 0.50 inch	None

Each separately poured lane of the pavement shall be cored as a unit, and all separately poured lanes of the same specified thickness composing the pavement shall be treated as constituting a single continuous lane for purposes of coring and in determining the linear extent of prescribed sections for calculating the average pavement thickness. The proportional deduction, if any, and the average thickness of the pavement shall be computed for each section thus defined.

The initial boring shall be made in the center of either outside pavement strip at a point 500 feet from the end of the pavement. This first boring shall be considered as the initial station, and subsequent borings shall be taken at the quarter point or along the center of the strips at 500-foot intervals. The odd distance left over at the end of any one strip shall be carried over and deducted in figuring the initial station on the adjacent strip. All stations shall start from the same end of the runway. No cores shall be taken within fifty (50) feet of the end of any runway strip. Cores shall not be taken near the intersection of a transverse and longitudinal joint.

Should any core show a thickness less than that allowed, additional cores shall be cut ten (10) feet, measured longitudinally, on each side of the location of the deficient core. If both these additional cores are within the one-half ($\frac{1}{2}$) inch tolerance no further special borings for this particular zone of deficiency shall be made. If either or both of the cores are not within the one-half ($\frac{1}{2}$) inch tolerance, the procedure shall be to cut further additional cores in the following locations: 50 feet and 100 feet, the same to be measured longitudinally from the location of the core originally found to be deficient in thickness, thence at 100-foot intervals longitudinally, until pavement thickness within the one-half ($\frac{1}{2}$) inch tolerance is found in both directions, but in no case shall additional cores be cut beyond the location of any specified boring in that strip at which the pavement thickness is found to be within the one-half ($\frac{1}{2}$) inch tolerance.

When any core shows a deficiency of more than one-half ($\frac{1}{2}$) inch the length of the adjacent pavement, for which payment shall be withheld, shall be the average of the distances measured parallel to the centerline, from the location at which the core originally found to be

deficient in thickness was cut, to the nearest boring in each direction longitudinally which produced a core within the one-half ($\frac{1}{2}$) inch tolerance. Deductions shall be only for the separately poured strip from which the core or cores deficient in thickness were cut.

All thickness measurements which are more than one-half ($\frac{1}{2}$) of an inch greater than the specified thickness shall be regarded as the specified thickness plus one-half ($\frac{1}{2}$) of an inch. In computing the average thickness of pavement, the mean thickness of any two longitudinally contiguous cores shall be considered the average thickness for that part of the pavement in that lane between the two pertinent borings, and the average thickness of those parts of the pavement between the initial station, and the initial boring made as specified, and the terminal station and the terminal boring made as specified shall be considered to be the same as the thickness of the initial and terminal cores, respectively. The average thickness of a prescribed section shall be the figure in inches arrived at as follows: The average thickness between each two longitudinally contiguous borings shall be multiplied by the number of feet of pavement between the two borings, and the sum of the results thus obtained divided by the total number of linear feet of concrete cored in the prescribed section, omitting all portions not within the one-half ($\frac{1}{2}$) inch tolerance.

In determining the thickness of the cores a standard highway core measuring device shall be used. The device intended is that which has three fingers mounted on an adjustable head which centers over the core. The fingers are spaced at 120° apart and are located midway between core center and core edge. The average of the three measurements shall be considered as the thickness of the core.

501-3.24 REQUIREMENTS FOR SMOOTHNESS. After the final curing of the concrete and the removal of the covering material, the surface shall be swept clean and tested by the engineer for smoothness by means of a "surface testing machine" or "mechanical straightedge" furnished by the contractor, which will test one or more lines as determined by the engineer on each separately poured lane of the pavement. All surface variations so indicated, one-fourth ($\frac{1}{4}$) of an inch or more in a sixteen (16) foot length of pavement, must be ground off in a manner satisfactory to the engineer. Bush hammering will not be permitted.

Sections of pavement containing extreme depressions with a depth in excess of one-fourth ($\frac{1}{4}$) of an inch in sixteen (16) feet shall be removed and replaced by the contractor at his own expense. In no case shall such section be less than the full width of the slab in which the depression occurs, or for a length of less than ten (10) feet.

501-3.25 STEEL REINFORCEMENT. Steel reinforcement shall be clean, free from rust in the form of loose or objectionable scale, and of type and dimensions shown on the plans. The materials shall conform to the requirements in paragraph 2.7.

Wires used in welded wire fabric shall be not smaller than No. 6 gauge (nominal diameter 0.1920 inch). Longitudinal bars in bar

mats may be either one-fourth ($\frac{1}{4}$) of an inch, three-eighths ($\frac{3}{8}$) of an inch, or one-half ($\frac{1}{2}$) of an inch diameter; and transverse bars may be either one-fourth ($\frac{1}{4}$) of an inch or three-eighths ($\frac{3}{8}$) of an inch diameter.

Longitudinal members in welded wire fabric shall be spaced not less than four (4) inches nor more than six (6) inches center to center; and, in bar mats, not less than six (6) inches nor more than twelve (12) inches center to center. Transverse members in welded wire fabric shall be spaced not less than six (6) inches nor more than twelve (12) inches center to center; and in bar mats, not less than six (6) inches nor more than eighteen (18) inches center to center.

Ends and sides of adjacent sheets or mats shall be overlapped to provide continuous reinforcing throughout each slab panel. The center of end laps of sheets or mats (transverse laps) shall be located at least two (2) feet from transverse dummy joints; and the center of side laps (longitudinal laps) at least two (2) feet from longitudinal dummy joints. Longitudinal and transverse members of bar mats shall be lapped at least forty (40) bar diameters. Longitudinal members of wire fabric sheets shall be lapped at least forty (40) wire diameters but not less than twelve (12) inches; and transverse members shall be lapped at least six (6) inches as measured between centers of the outside longitudinal wires of overlapping sheets.

501-3.26 PLACING REINFORCEMENT. The concrete shall be struck off by means of a mechanical templet, to the proper depth below the specified finished surface, before reinforcement is placed. The reinforcing steel and the top layer of concrete shall be placed within thirty (30) minutes after the concrete is struck off. The reinforcing steel shall be placed two (2) inches below and parallel to the finished surface of the pavement, unless otherwise shown on the plans. The steel shall not extend across the expansion or contraction joints, but shall be discontinued two (2) inches back from the joints. The reinforcing sheets and mats shall be laid with the main members of the long axis of the opening parallel with the centerline of the pavement. Adjacent sheets of the reinforcing steel shall be lapped not less than twelve (12) inches when the lap is made perpendicular to the centerline of the pavement and not less than six (6) inches when made parallel to the centerline of the pavement.

The sheets forming each lap shall be securely wired or clipped together at the edges of the sheets, with similar fastenings spaced evenly between, at distances not to exceed forty-two (42) inches.

501-3.27 OPENING TO TRAFFIC. The pavement shall be closed to traffic, including the vehicles of the contractor, for a period of ten (10) days after the concrete is placed, or longer if, in the opinion of the engineer, the weather conditions make it necessary to extend this time. The contractor shall furnish, place, and maintain satisfactory barricades and lights, as directed, to exclude all traffic from the pavement. Any damage resulting to the pavement due to traffic shall be repaired or replaced at the expense of the contractor.

314 501. PORTLAND CEMENT CONCRETE PAVEMENT

Power shovels, cranes, paving mixers, and similar heavy equipment shall not be moved or operated on the pavement without the written approval of the engineer. The pavement shall not be opened to traffic until all joints have been filled and sealed.

METHOD OF MEASUREMENT

501-4.1 The yardage to be paid for shall be the number of square yards of either plain or reinforced pavement as specified, in place, completed and accepted, less deductions as hereinabove required for deficient thickness.

BASIS OF PAYMENT

501-5.1 The yardage measured, as provided above, shall be paid for at the contract unit price per square yard bid for plain or reinforced Portland cement concrete pavement, which price and payment shall constitute full compensation for furnishing and preparation of all materials, including such transverse and longitudinal joints, reinforcing steel, joint filler, dowels or load-transfer devices, as are required in the plans; for placing, finishing, and curing; for all labor, equipment, tools, and incidentals necessary to complete the item; provided, however, that said unit price shall be reduced when and as required hereinabove for deficient thickness.

Payment will be made under:

Item P-501-5.1	Portland Cement Concrete Pavement—per square yard.
----------------	--

MISCELLANEOUS

ITEM P-602 BITUMINOUS PRIME COAT

DESCRIPTION

602-1.1 This item shall consist of an application of bituminous material on the prepared base course in accordance with this specification and at the rate of application ordered by the engineer. The type of bituminous material to be used will be selected by the engineer from those included in this specification.

602-1.2 QUANTITIES OF BITUMINOUS MATERIAL. The approximate amount of bituminous material per square yard for the prime coat shall be as provided in the table. The exact amount to be used shall be determined by the engineer.

TABLE 1.—*Quantities of Material*

Material	Amount
Bituminous material.....	0.25 to 0.50 gallon per square yard.

MATERIALS

602-2.1 MATERIALS. The bituminous material to be used for the prime coat shall conform to the kind, grade, and specifications as follows:

Refined tar, grade RT-2, RT-3—conforming to the requirements of A. A. S. H. O. Specification M-52.

Medium curing cut-back asphalt, MC-0, MC-1—conforming to the requirements of A. A. S. H. O. Specification M-82.

CONSTRUCTION METHODS

602-3.1 WEATHER LIMITATIONS. The prime coat shall be applied only when the existing surface is dry or contains sufficient moisture to get uniform distribution of the bituminous material when the atmospheric temperature is above 60° F., and when the weather is not foggy or rainy. The temperature requirements may be waived, but only when so directed by the engineer.

602-3.2 EQUIPMENT. The equipment used by the contractor shall include a self-powered pressure bituminous material distributor, and equipment for heating bituminous material.

The distributor shall have pneumatic tires of such width and number that the load produced on the base surface shall not exceed 650 pounds per inch of tire width and shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gauges, volume-measuring devices, and a thermometer for reading temperatures of tank contents.

Equipment for heating bituminous material shall consist of a tank with steam coils so designed that steam will not be introduced into the material. Other approved equivalent heating facilities may be used.

602-3.3 APPLICATION OF BITUMINOUS MATERIAL. Immediately before applying the prime coat, if the surface is sufficiently bonded, the full width of the surface to be primed shall be swept with a power broom equipped with blower. In any case care shall be taken to remove all loose dirt and clay or other loose and objectionable material.

After the operation of removing the dust has been completed, and prior to the application of the prime coat, an inspection shall be made of the base to determine its fitness to receive the bituminous priming material. That portion of the base proposed for immediate treatment, if very dry, shall be lightly sprinkled immediately in advance of the application, as directed.

The application of the bituminous priming material shall be by means of a pressure distributor of approved type, and shall be made at the pressure and in the amounts as directed by the engineer. The temperature of application shall be between 80° F. and 150° F. for tar; for MC-0 cut-back, the temperature range shall be between 50° F. and 125° F.; and for MC-1 cut-back, between 100° F. and 175° F.

Following the application, the primed surface shall be allowed to dry for a period of not less than forty-eight (48) hours without being disturbed, or for such additional period of time as may be necessary to permit the drying out of the prime until it will not be picked up by traffic or equipment, which period shall be determined by the engineer. The surface shall then be maintained by the contractor until the surfacing has been placed. Suitable precautions shall be taken by the contractor to protect the prime surface against damage during this interval, including supplying and spreading any sand necessary to blot up excess bituminous material.

602-3.4 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous materials that the

contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such materials begins. The contractor shall require the manufacturer or producer of the bituminous materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of bituminous material shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

602-3.5 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken by the engineer, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

602-4.1 The gallonage of bituminous prime coat to be paid for shall be the number of gallons of the material used as ordered for the accepted work, corrected to gallons at 60° F., in accordance with A. S. T. M. Designation D-206, for asphalt materials, and in accordance with an appropriate table for tars; provided, however, that the measurement shall be in tons (2,000 pounds) in cases where the bid schedule calls for tons of bituminous material.

BASIS OF PAYMENT

602-5.1 The gallonage or tonnage, determined as provided above, shall be paid for at the respective contract unit price per gallon or ton in the bid schedule for bituminous prime coat, which price and payment shall be full compensation for furnishing, delivering, and applying the material; for cleaning surface; for furnishing and spreading blotter material; for all labor, equipment, and tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-602-5.1 Bituminous Prime Coat—per gallon or per ton.

ITEM P-603 BITUMINOUS TACK COAT

DESCRIPTION

603-1.1 This item shall consist of supplying and applying bituminous material to a previously prepared, bonded and/or bituminized binder, leveling, or base course or existing pavement in accordance with these specifications and to the width shown on the typical cross section on the plans.

603-1.2 QUANTITY OF MATERIAL. The approximate amount of bituminous material per square yard for the tack coat shall be as provided in the table. The exact amount shall be as ordered by the engineer.

TABLE 1.—*Quantity of Material*

Material	Amount
Bituminous material including vehicle or solvent-----	0.05 to 0.20 gallon per square yard.

MATERIALS

603-2.1 BITUMINOUS MATERIAL. The bituminous material to be used shall conform to the kind, grade, and specifications as follows:

Rapid-curing cut-back asphalt, grade RC-2, RC-3, RC-4—conforming to the requirements of A. A. S. H. O. Specification M-81. The grade of cut-back asphalt shall be indicated in the proposal or shown on the plans. The asphalt cement shall meet the requirements of A. A. S. H. O. Specification M-20. The penetration grade shall be between 100 and 150, or as directed by the engineer.

The 90+ asphalt cement shall be homogeneous, free from water, and shall not foam when heated to a temperature of 347° F. The cement shall meet the requirements of Table 2.

TABLE 2.—*Requirements for 90+ Asphalt Cement*

Test requirements	A. A. S. H. O. test method	Limits	
		Min.	Max.
Water, percent.....	T-55		0
Furol Viscosity, at 210° F.....	T-72	250	500
Flash Point, ° F. (Cleve. Open Cup).....	T-48	275	
Distillation:			
Total distillate to 680° F., percent by volume.....	T-78		2
Float test on residue at 122° F., sec.....	T-50	150	350
Asphalt residue of 100 penetration, percent.....	T-56	90	
Ductility of asphalt residue at 77° F., cms.....	T-51	100	
Percent soluble in CCl ₄ (using CCl ₄ with T-44).....		99.5	
Temperature of Application, ° F.....		200	275

The material shall not be cracked.

The emulsified asphalt shall be homogeneous, of such character that it will mix with distilled water in all proportions, and shall meet the following requirements:

TABLE 3.—*Requirements for Emulsified Asphalt*

Test requirements	A. A. S. H. O. test method	Limits
Viscosity, Saybolt Furol, at 77° F. sec.....	T-59	20-120
Residue at 325° F., percent.....	T-59	55-60
Demulsibility: 35 c. c. N/50 CaCl ₂ , not less than, percent.....	T-59	60
Sieve Test, not more than, percent.....	T-59	0.10
Settlement 5 days, not more than, percent.....	T-59	5
Sampling Material.....	T-40	

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F., not less than.....	T-43	0.96
Penetration at 77° F., 100 g., 5 sec.....	T-49	100-300
Soluble in Carbon Tetrachloride, not less than, percent.....	T-45	97.5
Ductility at 77° F., not less than, cm.....	T-51	40
Temperature of Application, ° F.....		50-125

The material shall not be cracked.

CONSTRUCTION METHODS

603-3.1 WEATHER LIMITATIONS. The tack coat shall be applied only when the existing surface is dry, when the atmospheric temperature is above 60° F., and when the weather is not foggy or rainy. The temperature requirements may be waived, but only when so directed by the engineer.

603-3.2 EQUIPMENT. The equipment used by the contractor shall include a self-powered pressure bituminous material distributor, and equipment for heating bituminous material.

The distributor shall have pneumatic tires of such width and number that the load produced on the course shall not exceed 650 pounds per

inch of tire width, and shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, and a thermometer for reading temperatures of tank contents.

Equipment for heating bituminous material shall consist of a tank with steam coils so designed that steam will not be introduced into the material. Other approved equivalent heating facilities may be used.

603-3.3 APPLICATION OF BITUMINOUS MATERIAL.

Immediately before applying the tack coat, if the surface is sufficiently bonded, the full width of surface to be treated shall be swept with a power broom equipped with blower, supplemented by hand brooms, if necessary, or otherwise as directed by the engineer. In any case care shall be taken to remove all loose dirt and clay or other loose and objectionable material.

After the operation of removing the dust has been completed, and prior to the application of the tack coat, an inspection shall be made of the binder, leveling, or base course to determine its fitness to receive the bituminous material. That portion of the surface of the course proposed for immediate treatment must be dry and altogether in a satisfactory condition.

The application of the bituminous tack material shall be made by means of a pressure distributor of approved type, and shall be made at the pressure and in amounts as directed by the engineer. The temperature of application for cut-back asphalt and asphalt cement shall be as follows:

RC-2-----	125°-175° F.
RC-3-----	150°-200° F.
RC-4-----	175°-225° F.
Asphalt cement-----	200°-300° F.

The temperature of application for the 90+ asphalt cement and the emulsified asphalt shall be as shown in the tables.

Following the application, the surface shall be allowed to cure without being disturbed for such period of time as may be necessary to permit drying out and setting of the tack coat, which period shall be determined by the engineer. The surface shall then be maintained by the contractor until the next course has been placed. Suitable precautions shall be taken by the contractor to protect the surface against damage during this interval, including any sand necessary to blot up excess bituminous material.

603-3.4 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous material that the contractor proposes to use, together with a statement as to its source and character, must be submitted and approval obtained before use of

such material begins. The contractor shall require the manufacturer or producer of the bituminous material to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been demonstrated by service tests as satisfactory for the intended use will be acceptable.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of bituminous material shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

603-3.5 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken by the engineer, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

603-4.1 The gallonage of bituminous tack coat to be paid for shall be the number of gallons of the material used as ordered for the accepted work, corrected to gallons at 60° F., in accordance with A. S. T. M. Designation D-206, for asphalt materials and in accordance with an appropriate formula or table for emulsified asphalt; provided, however, that the measurement shall be in tons (2,000 pounds) in cases where the bid schedule calls for tons of bituminous material.

BASIS OF PAYMENT

603-5.1 The gallonage or tonnage of bituminous tack coat, determined as provided above, shall be paid for at the respective contract unit price per gallon or ton in the bid schedule for bituminous tack coat, which price and payment shall be full compensation for furnishing, delivering, and applying the material; for cleaning the course; for covering excess bituminous material; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-603-5.1 Bituminous Tack Coat—per gallon or per ton.

ITEM P-604 BITUMINOUS SEAL COAT

DESCRIPTION

604-1.1 This item shall consist of a seal coat of bituminous material with cover aggregate, constructed on the properly cured wearing surface in accordance with these specifications and to the width shown on the typical cross section on the plans.

604-1.2 QUANTITIES OF MATERIALS PER SQUARE YARD. The approximate amounts of materials per square yard for the seal coat shall be as provided in Table 1. The exact amounts to be used shall be determined by the engineer.

TABLE 1.—Quantities of Materials

Materials	Amounts
Bituminous material.....	0.15-0.30 gallon per square yard
Cover aggregate.....	7-20 lbs. per square yard

MATERIALS

604-2.1 COVER AGGREGATE. Cover aggregate as applied shall meet the gradation given in Table 2. The test for gradation shall be made using A. A. S. H. O. Method T-27.

TABLE 2.—Requirements for Gradation of Aggregate

Sieve designation	Percentage by weight passing square mesh sieves
1/4-inch.....	100
No. 4.....	70-100
No. 10.....	10- 50
No. 40.....	0- 5
No. 100.....	0- 1

Cover aggregate for seal shall be a light colored material consisting of crushed stone free from dirt or organic matter. Acceptable material shall be equal in color and reflectivity to that from approved sources.

Crushed cover aggregate shall be free from clay balls and adherent films of clay, or rock dust, and shall be washed thoroughly if produced in a damp condition. Aggregate shall be of such nature that a thorough coating of the bituminous material to be used in the work applied to it will not slough off upon contact with water. The aggregate shall not contain more than three (3) percent moisture at the time of application. Heating of the aggregate shall be used if necessary to reduce the moisture content to three (3) percent or less. The use of pretreated aggregates for the control of stripping may be allowed in lieu of drying, providing the moisture content is three (3) percent or less, if approved by the engineer. A sample of crushed stone, from which the crushed cover aggregate is produced, shall have a percent of wear of not more than 45 at 500 revolutions, as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

604-2.2. BITUMINOUS MATERIALS. The material furnished shall be one of the following types or as provided for in the proposal:

Rapid curing cut-back asphalt, Grade RC-2, conforming to the requirements of A. A. S. H. O. Specification M-81.

The emulsified asphalt shall be homogeneous, of such character that it will mix with distilled water in all proportions, and shall meet the following requirements:

TABLE 3.—Requirements for Emulsified Asphalt

Test requirements	A. A. S. H. O. Test method	Limits
Viscosity, Saybolt Furol at 77° F., sec., not less than....	T-59	100
Residue at 325° F., percent.....	T-59	55-65
Demulsibility, 35 ml. N/50 CaCl ₂ , not less than, percent.....	T-59	60
Settlement, 10 days, not more than, percent.....	T-59	3
Sieve Test, not more than, percent.....	T-59	.05

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F., not less than.....	T-43	1.00
Penetration at 77° F., 100 g., 5 sec.....	T-49	100-300
Soluble in Carbon Tetrachloride, not less than, percent.....	T-45	97
Ash, not more than, percent.....	T-59	2
Ductility at 77° F., not less than, cms.....	T-51	40

The material shall not be cracked.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot, and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility. The test for cracked material shall be made on the asphalt prior to emulsification.

CONSTRUCTION METHODS

604-3.1 WEATHER LIMITATIONS. Seal coats shall be applied only when the existing surface is dry, when the atmospheric temperature is above 60° F., and when the weather is not foggy or rainy. Seal coating shall not be attempted except under favorable weather conditions.

604-3.2 EQUIPMENT. The equipment used by the contractor shall include a power broom or a power blower, broom dragging equipment, a standard multiwheeled rubber-tired roller or other rubber-tired equipment that will produce equal results, aggregate-spreading equipment that can be so adjusted as to spread accurately the given amounts per square yard, a self-powered pressure bituminous material distributor, equipment for heating bituminous material, and equipment for heating aggregate, when needed.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer. The weight of the roller shall be increased as the rolling progresses to the maximum degree obtainable without detrimental results to the wearing surface.

The distributor shall have pneumatic tires of such width and number that the load produced on the runway surface shall not exceed 650 pounds per inch of tire width, and shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, and a thermometer for reading temperatures of tank contents.

Equipment for heating bituminous material shall consist of a tank with steam coils so designed that steam will not be introduced into the material. Other approved equivalent heating facilities may be used.

604-3.3 CLEANING EXISTING SURFACE. Prior to placing the seal coat, loose dirt and other objectionable material shall be removed from the existing surface. If so directed by the engineer, the surface shall be cleaned with a power broom or power blower.

604-3.4 APPLICATION OF BITUMINOUS MATERIAL. Bituminous material shall be so applied that uniform distribution is obtained at all points. Unless the distributor is so equipped as to obtain this result at the junctions of applications, building paper shall be spread on the surface for a sufficient distance back from the end of each application so that flow through sprays may be started and

stopped on the paper, and so that all sprays will operate properly over the entire length being treated. Building paper so used shall be immediately removed and burned. Application temperatures shall be between 120° F. and 175° F. for cut-back asphalt, and between 50° F. and 120° F. for emulsified asphalt. During all applications the surfaces of adjacent structures shall be protected in such manner as to prevent their being spattered or marred. Bituminous material shall not be discharged into borrow pits or gutters or upon airport areas. Areas inaccessible to the distributor may be sprayed by hand method.

The bituminous material shall not be applied until the cover aggregate is available and ready for spreading. The temperature of the aggregate shall not be in excess of 150° F. No bituminous material shall be placed which cannot be covered during daylight.

604-3.5 SPREADING COVER AGGREGATE. The covering material in the quantity specified shall be spread uniformly over the bituminous material as soon after application as is possible. The aggregate shall be spread in the same width of application as for the bituminous material, and applied uniformly with the aggregate-spreading equipment. Hand-spreading methods may be used when permitted by the engineer. Trucks spreading aggregate shall be operated backward so that bituminous material will be covered before truck wheels pass over it. The aggregate shall not be applied in such thickness to cause blanketing. Back-spotting or sprinkling of additional aggregate over areas that show up as having insufficient cover shall be done by hand-spreading, which shall be continued during the operations whenever necessary.

604-3.6 BROOMING AND ROLLING. Rolling shall be started as soon as sufficient aggregate is spread to prevent pick-up and continued until no more aggregate can be worked into the surface. The broom-dragging should start as soon as possible after the rolling has started and the surface has set sufficiently to prevent excessive marking of the seal surface. Further broom-dragging should be done as often as necessary to keep cover aggregate uniformly distributed over the runway surface. Broom-dragging, rolling, and back-spotting shall be continued until the surface is cured to the satisfaction of the engineer. All surplus aggregate shall be swept off the surface and removed prior to final acceptance.

604-3.7 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous material that the contractor proposes to use, together with a statement as to its source and character, must be submitted and approval obtained before use of such material begins.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of bituminous material shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted

as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

604-3.8 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and covering materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken by the engineer, nor shall the car or tank be released until outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

604-4.1 The unit of measurement of bituminous seal coat material shall be the gallon or ton. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered for the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F. or by converting the gallonage measured at other temperature to gallonage at 60° F., in accordance with A. S. T. M. Designation D-206 for asphalt, or in accordance with a coefficient of expansion of 0.00025 per degree F. for emulsified asphalt.

604-4.2 The tonnage of cover aggregate to be paid for shall be the number of tons of aggregate used as ordered for the accepted work or placed in authorized stock-piles.

BASIS OF PAYMENT

604-5.1 The quantities of bituminous material and aggregate, determined as provided in 4.1 and 4.2 above, shall be paid for at the respective contract unit prices per gallon or per ton for bituminous material for seal coat and per ton for cover aggregate, which prices and payments shall constitute full compensation for furnishing, delivering, and placing all materials; for brooming, compacting, and rolling; for cleaning the existing surface; for covering excess bituminous material; for removal of excess aggregate; for reconditioning of shoulders and cleaning gutters; for clearing, cleaning, and leveling stock-pile sites; for furnishing and sealing of scales; for furnishing the weigh house; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item P-604-5.1 Bituminous Seal Coat—per gallon or per ton.

Item P-604-5.1 Cover Aggregate—per ton.

ITEM P-605 JOINT SEALING FILLER

(Hot-poured Type for Concrete)

DESCRIPTION

605-1.1. This item shall consist of a joint sealing filler (Hot-poured Type) composed of a mixture of materials which will form a resilient and adhesive sealing compound capable of effectively sealing joints in Portland cement concrete pavements and structures.

REQUIREMENTS

605-2.1 GENERAL REQUIREMENTS. The filler material furnished shall be suitable for melting in a heating kettle or tank, constructed as a double boiler, with a space between the inner and outer shells filled with a material for heat transfer and positive temperature control. The filler shall melt to the proper consistency for pouring, and shall solidify on cooling to atmospheric temperature. It shall adhere to the sides of the concrete joint or crack. The filler shall not crack or break when exposed to low temperatures and extended.

605-2.2 DETAILED REQUIREMENTS. A sample of the filler weighing approximately three hundred (300) grams shall be selected in such a manner as to avoid inclusion of the surface layer. Of this quantity, one hundred (100) grams shall be melted slowly with continued stirring to a pouring consistency, in a clean container using an oil bath or similar heating unit, to avoid local overheating. The remaining two hundred (200) grams shall be added in quantities of approximately fifty (50) grams at a time to the melted material until the entire quantity is of a sufficiently fluid consistency to be poured satisfactorily.

The melting of the total quantity of material shall be completed within sixty (60) minutes of the initial heating of the material. At no time shall the temperature of the sample exceed 450° F.

(a) *Penetration.* The penetration of the filler sampled and molten (as herein described), when tested with a Penetrometer according to A. S. T. M. Designation D-5 with a grease cone (D-217) attachment, shall be as follows:

0° C. (32° F.), 200 g. weight, 60 secs.—0.28 to 0.38 cm.

25° C. (77° F.), 150 g. weight, 5 secs.—0.45 to 0.75 cm.

(b) *Flow.* A portion of the molten sample shall be poured into a suitable amalgamated mold four (4) cms. wide by six (6) cms. long, on a bright tin panel to a uniform depth of thirty-two hundredths

(0.32) cm. After cooling at room temperature for two (2) hours, the mold shall be removed and the panel placed in an oven at 140° F. (+ or -2°) at an incline of seventy-five (75) degrees for five (5) hours. The material shall not flow more than one-half ($\frac{1}{2}$) cm. as a result of this test.

605-2.3 SPECIAL REQUIREMENTS. The joint sealing filler, as used in the field and for these tests, shall be melted slowly with continued stirring at a temperature not to exceed its initial ready pouring fluidity. At no time shall the temperature of the material exceed 450° F. In addition to the tests described above, the material shall be tested for adhesion and elasticity as follows:

(a) *Test Specimen.* A test specimen shall consist of two (2) cement mortar pieces, approximately one (1) by two (2) by three (3) inches (1" x 2" x 3"), made of a cement mortar, consisting of one (1) part by weight of Portland cement to two (2) parts by weight of clean, uniformly graded sand, one hundred percent passing a number 4 mesh sieve and zero (0) to five (5) passing a number 100 mesh sieve. The cement mortar mix shall be made to a consistency of 50 (+ or -5), as measured by the standard A. S. T. M. mortar flow table.

After having been cured for seven (7) days, the wet mortar pieces shall be resurfaced by grinding with a standard number 30 H. D. carborundum stone on a standard delemeter at a pressure of fifteen (15) to twenty (20) pounds. The surfaces of the mortar pieces shall, upon examination, show that the aggregate is uniformly exposed. The concrete pieces shall then be permitted to air-dry at room temperature (77° F.) for twenty-four (24) hours prior to use.

The completed mortar pieces shall be spaced one (1) inch apart on a plate of amalgamated metal, and shall be held apart by amalgamated metal strips spaced at such distances from the ends that a space one (1) inch by two (2) inches by two (2) inches (1" x 2" x 2") is formed for pouring with the joint sealing filler material to be tested. The test joint form may be held together by rubber bands or suitable clamps.

(b) *Freezing.* A test specimen (as herein described) shall be allowed to cool in air at room temperature for two (2) hours; thereafter placed in a refrigerating unit being maintained at 0° F. (+ or -2°) for a minimum of six (6) hours.

(c) *Bond and Extension While Frozen.* (1) The specimen, while at a temperature of 0° F. (+ or -2°), shall be removed from the amalgamated plate and strips and then immediately placed in the self-aligning clamps of the extension machine (described below), maintained at a temperature of 0° F. (+ or -2°) in a refrigerating unit. The extension machine shall then extend the width of the specimen at the rate of approximately one-eighth ($\frac{1}{8}$) inch per hour to a width fifty (50) percent greater than its original poured width.

(2) *Extension Machine.* The extension machine shall be so designed that the specimen can be expanded uniformly at the rate of approximately one-eighth ($\frac{1}{8}$) inch per hour. The extension ma-

chine shall consist essentially of one or two screws, rotated by an electric motor, through suitable gear reduction units. The screw or screws shall carry a threaded moving self-aligning plate to which, and to a stationary plate, the specimen is clamped.

(d) *Compression.* After having been extended to the required width, the specimen shall be removed and placed at room temperature (approximately 77° F.) for two (2) hours; thereafter compressed to its thickness before extension at the rate of one-tenth (0.1) inch per minute. During this compression, the specimen is to be maintained in a horizontal position.

(e) The specimen is then again placed in the refrigerating unit, and the extension and compression tests repeated for four (4) cycles, as described above.

There shall be no cracking of the joint-sealing filler or break in the bond between the joint-sealing filler and the mortar pieces.

CONSTRUCTION METHODS

605-3.1 WEATHER LIMITATIONS. The pouring of joints in concrete shall be undertaken only when the surface and the joints are dry, when the atmospheric temperature is above 40° F., and when the weather is not foggy or rainy. The temperature requirements may be waived, but only when so directed by the engineer.

605-3.2 EQUIPMENT. All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The heating apparatus shall consist of a heating kettle or tank, constructed as a double boiler, with a space between the inner and outer shells filled with oil, asphalt, or other material for heat transfer and positive temperature control. Other methods of indirect heating approved by the engineer may be used. Direct heating shall not be used. The heating and melting unit shall be equipped to provide control of the temperature of the heating medium used for melting the joint-sealer. The joint-sealer shall not be subjected to temperature in excess of 450° F. at any stage or any points in the melting and pouring operation.

The joint-pouring equipment may consist of a hand-pouring pot, or a mechanical pouring kettle mounted on wheels with a pouring shoe, or the pouring shoe may be mounted on a swivel-jointed discharge line at the rear of a truck on which the heating and melting unit is carried. The pouring pot, the pouring shoe, or any other approved method, shall be designed to place the sealer material to the required depth, width, and distance below the concrete surface, as shown on the plans or as required by the engineer.

The equipment for cleaning the joint space and areas for new construction shall consist of such plows, powered and hand brooms or brushes, and blowers as are necessary to produce a satisfactory clean

joint. Similar approved mechanical equipment shall be provided for cleaning joints previously sealed.

Sufficient testing equipment shall be provided to determine and control temperatures on the project; also for taking samples in the field for making flow tests on panels.

605-3.3 PREPARATION OF JOINTS. The joints shall be thoroughly cleaned of all loose scale, dirt, and dust; when needed, the existing joint material shall be removed to the depth as shown on the plans or as directed. The term "joint" is intended to include wide joint space such as an expansion joint, a dummy groove joint, or a crack, either preformed or natural. Asphalt stain will not be classed as objectionable. Concrete surfaces or areas adjacent to the joints shall be cleaned of all loose material.

605-3.4 FIELD PREPARATION OF JOINT-SEALER.

The joint-sealer shall be melted in a kettle or tank, as specified, and heated to the required temperature for easy pouring. The material shall not be heated in excess of 450° F. at any stage in the melting process. Once the material has been heated it shall be maintained at an even temperature until placed into the joint.

605-3.5 POURING JOINT-SEALER. The joints shall be filled to the depth as shown on the plans. Pouring shall be done in a neat and workmanlike manner. Pouring shall be done by the methods required which shall give satisfactory results. Sufficient joint-sealer shall be poured into the joints so that, upon completion of the work, the surface of the sealer within the joint shall be not less than one-quarter ($\frac{1}{4}$) of an inch below the level of the adjacent pavement surface, or at the elevation as directed. All joints shall be surface dry and clean before the application of the joint-sealer.

605-3.6 FIELD TEST. Prior to the start of pouring the joints, the contractor will be required to demonstrate that the equipment for heating and melting the sealer will produce a material of the proper consistency, and that the flow test panels prepared from samples taken from this material in the field will meet the field flow test requirements. The demonstration shall include the melting of at least two batches of joint-sealing material, and making of at least two flow test panels for each batch. These flow tests shall be made in the laboratory, and as required in this specification. These samples shall have a flow not in excess of two centimeters. Materials indicating a flow in excess of two centimeters shall be rejected. Flow test panels shall be prepared for test at least once each day during the operations of pouring joints subsequent to the initial demonstration. These samples shall indicate that the joint material used on the project meets the flow test.

METHOD OF MEASUREMENT

605-4.1 The joint-sealing filler to be paid for shall be either the pounds or gallons of filler as specified, in place, complete and accepted. When required in the construction of concrete pavements or struc-

tures, no measurement will be made for direct payment of filler, as the cost of furnishing and installing shall be considered as a subsidiary obligation in the completion of the construction.

BASIS OF PAYMENT

605-5.1 The amount of the joint-sealing filler, as determined above, shall be paid for at the respective contract unit price per pound or per gallon used as ordered in the accepted work, which price and payment shall constitute full compensation for furnishing and installing; for clean-up; for all labor, equipment, tools, and incidentals necessary to complete the item. As stated above, when the filler is required in the construction of concrete pavements or structures, performance of this item will not be payable directly, but shall be considered as a subsidiary obligation of the contractor covered under the contract unit prices for square yards of concrete pavement, or cubic yards of concrete structures.

Payment will be made under:

Item P-605-5.1 Joint-Sealing Filler—per pound or per gallon.

ITEM P-609 BITUMINOUS SURFACE TREATMENT

DESCRIPTION

609-1.1 This item shall consist of a bituminous surface treatment as a wearing course composed of two applications of bituminous material and aggregate cover placed on the prepared underlying course, in accordance with these specifications and in conformity with the dimensions and typical cross section shown on the plans, and with lines and grades established by the engineer.

609-1.2 QUANTITIES OF MATERIALS PER SQUARE YARD. The approximate amounts of materials per square yard for the bituminous surface treatment shall be as provided in Table 1. The exact amounts to be used shall be determined by the engineer.

TABLE 1.—*Quantities of Materials*

Materials	Amounts
<i>First Application</i>	
Bituminous material.....	0.30 to 0.50 gallon per square yard.
Aggregate material.....	20 to 35 pounds per square yard.
<i>Second Application (Seal coat in accordance with Item P-604).</i>	
Bituminous material.....	0.15 to 0.30 gallon per square yard.
Cover aggregate material.....	7 to 20 pounds per square yard.

The weights of aggregate given in Table 1 are for those aggregates having a bulk specific gravity of 2.65, as determined by A. A. S. H. O. Method T-85. Proportionate corrections shall be made when the aggregates furnished on the job have bulk specific gravities above 2.75 or below 2.55.

MATERIALS

609-2.1 AGGREGATE MATERIALS. The aggregate material shall be either crushed stone, crushed gravel, or crushed slag. The cover material shall be screenings; sand may be used when specified.

If the material is to be crushed stone, it shall be manufactured from sound, hard, and durable rock of accepted quality and crushed to specification size. All strata, streaks, and pockets of clay, dirt, sandstone, soft rock, or other unsuitable material occurring with the sound rock shall be discarded and not allowed to enter the crusher.

If the material is to be crushed gravel, it shall consist of hard, durable, fragments of stone or gravel of accepted quality and crushed

to specification size. All strata, streaks, and pockets of sand, excessively fine gravel, clay, or other unsuitable material including all stones, rocks, and boulders of inferior quality shall be discarded and not allowed to enter the crusher. The crushing of the gravel shall result in a product that, when separated on No. 4, $\frac{3}{8}$ -inch and $\frac{1}{2}$ -inch square opening sieves, shall contain in each size not less than seventy-five (75) percent of particles with at least one fractured face.

Crushed slag shall be air-cooled blast furnace slag, reasonably uniform in density and quality, and shall weigh not less than sixty-five (65) pounds per cubic foot.

The crushed aggregate shall be free from an excess of elongated or flat particles and from wood, roots, vegetable, organic, or other extraneous matter. The crushed coarse aggregate shall have a percent of wear of not more than 45 at 500 revolutions, as determined by A. A. S. H. O. Method T-96 (Los Angeles Rattler Test).

The aggregate shall not show evidence of disintegration, nor show a total loss greater than twelve (12) percent, when subjected to five (5) cycles of the sodium sulphate accelerated soundness test using A. A. S. H. O. Method T-104.

The crushed aggregate for the first application shall meet the requirements for gradation given in Table 2 using A. A. S. H. O. Methods T-11 and T-27.

TABLE 2.—*Requirements for Gradation of Aggregate*

Sieve designation	Percentage by weight passing square openings	
	No. 7	No. 8
$\frac{3}{4}$ -inch.....	100	-----
$\frac{1}{2}$ -inch.....	90-100	100
$\frac{3}{8}$ -inch.....	40- 70	85-100
No. 4.....	0- 15	10- 30
No. 8.....	0- 5	0- 10
No. 100.....	-----	0- 2

The gradations in the table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The final gradations decided on, within the limits designated in the table, shall be uniformly graded from coarse to fine.

The screenings for seal coat cover shall meet the requirements for quality and gradation of Item P-604.

Sand, when allowed for seal coat cover, shall meet the requirements for gradation of Item P-604. The sand shall consist of grains of quartz or other hard, durable rock, moderately sharp, and free from a coating of any injurious material. The sand shall be free from lumps of clay, loam, organic matter, or other foreign substances. Sand shall be of such nature that a thorough coating of the bituminous material, to be used in the work, applied to it will not slough off

upon contact with water. The sand shall not contain more than three (3) percent moisture at the time of application.

609-2.2 BITUMINOUS MATERIALS. The bituminous material furnished shall conform to the grade and requirements as specified and as provided for in the proposal:

Rapid curing cut-back asphalt, Grade RC-2, RC-3—conforming to the requirements of A. A. S. H. O. Specification M-81.

The asphalt cement shall meet the requirements of A. A. S. H. O. Specification M-20. The penetration grade shall be between 150 and 225.

The 90+ asphalt cement shall be homogeneous, free from water, and shall not foam when heated to a temperature of 347° F. The cement shall meet the following requirements:

TABLE 3.—Requirements for 90+ Asphalt Cement

Test requirements	A. A. S. H. O. test method	Min.	Max.
Water, percent.....	T-55	-----	0
Furol viscosity, at 210° F.....	T-72	250	500
Flash point, ° F. (Cleve. Open Cup).....	T-48	275	-----
Distillation:			
Total distillate to 680° F., percent by volume.....	T-78	-----	2
Float test on residue at 122° F., sec.....	T-50	150	350
Asphalt residue of 100 penetration, percent.....	T-56	90	-----
Ductility of asphalt residue at 77° F., cm.....	T-51	100	-----
Percent soluble in CCl ₄ (Using CCl ₄ with T-44).....	-----	99.5	-----
Temperature of application, ° F.....	-----	200	275

The material shall not be cracked.

The emulsified asphalt shall be homogeneous, of such character that it will mix with distilled water in all proportions, and shall meet the following requirements:

TABLE 4.—Requirements for Emulsified Asphalt

Test requirements	A. A. S. H. O. test method	Limits
Viscosity, Saybolt Furol at 77° F., sec., not less than.....	T-59	100
Residue at 325° F., percent.....	T-59	55-65
Demulsibility, 35 ml. N/50 CaCl ₂ , not less than, percent.....	T-59	60
Settlement, 10 days, not more than, percent.....	T-59	3
Sieve Test, not more than, percent.....	T-59	0.05

The residue from distillation shall have the following characteristics:

Specific Gravity at 77° F., not less than.....	T-43	1.00
Penetration at 77° F., 100 g., 5 sec.....	T-49	100-300
Soluble in Carbon Tetrachloride, not less than.....	T-45	97
Ash, not more than, percent.....	T-59	2
Ductility at 77° F., not less than, cms.....	T-51	40

The material shall not be cracked.

When the ductility test is made on the residue from distillation or evaporation, the residue shall be screened through a No. 50 mesh sieve while still hot, and shall then be kneaded until uniform and homogeneous. It shall then be tested for ductility. The test for cracked material shall be made on the asphalt prior to emulsification.

CONSTRUCTION METHODS

609-3.1 WEATHER LIMITATIONS. Bituminous material shall not be applied to wet aggregate material or during sand, dust, or rain storms. The pavement shall be free of surface moisture during the contractor's operating periods.

In general, it will be the policy not to permit the application of any bituminous material when the atmospheric temperature is less than fifty degrees Fahrenheit (50° F.); and if it is necessary to secure the best results, the engineer may require the contractor to delay the application of bituminous material until the atmospheric and pavement surface conditions are satisfactory. No bituminous material shall be placed which cannot be cared for during daylight hours.

609-3.2 OPERATION OF PITS AND QUARRIES. The aggregate material shall be obtained from pits, quarries, or sources that have been approved. The contractor shall make all necessary arrangements for obtaining the material, and all work involved in clearing and stripping pits or quarries and handling unsuitable material encountered shall be performed by the contractor at his own expense. The material in the pits shall be handled in a manner that a uniform and satisfactory product shall be secured. Pits shall be adequately drained, unless otherwise directed, and shall be left in a neat and presentable condition with all slopes dressed uniformly. Quarries shall be left in as neat and presentable condition as practicable.

609-3.3 EQUIPMENT AND ORGANIZATION. Each unit required in the execution of these specifications shall be under the continuous supervision of a competent superintendent thoroughly experienced in this class of work. Experienced operators will be required on all equipment used in hauling and applying bituminous material and aggregates.

All equipment necessary for the proper construction of this work shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The following equipment will be the minimum required for this type of construction, and additional machinery must be secured if, in the opinion of the engineer, it is necessary to fulfill the conditions of these specifications or to complete the improvement within the time specified.

The distributor shall have pneumatic tires of such width and number that the load produced on the pavement surface shall not exceed 650 pounds per inch of tire width and shall be so designed, equipped,

maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates of from 0.05 to 2.0 gallons per square yard, with a pressure range of from 25 to 75 pounds per square inch, and with an allowable variation from any specified rate not to exceed five (5) percent. Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, and a thermometer for reading temperatures of tank contents. The distributor shall have a minimum capacity of 1,000 gallons.

The steel-wheel rollers shall be of the self-propelled tandem or three-wheel type rollers weighing not less than three (3) tons nor more than eight (8) tons. The wheels on the rollers shall be equipped with adjustable scrapers which shall be used when necessary to clean the wheel surfaces. Rollers shall also be equipped with tanks and sprinkling apparatus which shall be used to keep the wheels wet and prevent the surfacing materials from sticking.

The pneumatic roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least sixty (60) inches, and shall give a compression of at least 275 pounds per inch of width of tread when fully loaded. The tires shall be uniformly inflated. The roller and the operating power unit shall meet the approval of the engineer.

The motor patrol grader shall be a modern unit, weighing not less than six (6) tons, with at least a ten (10) foot blade, and equipped with a wire-broom mould board.

The aggregate spreading equipment shall consist of a mechanical spreader box or tail-gate spreader attached to the rear of the hauling truck. The spreader shall be adjustable so as to spread accurately and evenly the required amounts per square yard. The spreader shall be supported on a wheel or wheels equipped with pneumatic tire or tires.

Equipment for heating bituminous material shall consist of a tank with steam coils so designed that steam will not be introduced into the material. Equivalent facilities that have been approved may be used.

The transfer supply tanks with a minimum of 1,000-gallon capacity shall be thoroughly insulated to retain heat. The number necessary shall depend on the length of haul from the source of supply and the rate of application of the bituminous material.

The contractor shall supply some auxiliary equipment, such as one or more stiff wire broom drags; one power broom, equipped with blower; and several hand push brooms, when required.

The number of pneumatic rollers furnished and operated on the project shall depend on the number of square yards of bituminous material distributed daily for each application of the surface treatment. A pneumatic roller shall be furnished for each ten thousand (10,000) square yards daily distribution of bituminous material.

609-3.4 PREPARING UNDERLYING COURSE. The surface of the underlying course shall be prepared, shaped, and conditioned to a uniform grade and section, as shown on the plans and specified. The surface shall then be swept free of dust and dirt by use of a power broom equipped with blower. The direction of the sweeping in each case shall be toward the outside edges of the pavement, unless otherwise directed by the engineer. The sweeping shall continue until all dust, dirt, or loose material has been removed. Hand push brooms shall be used to clean any omissions of the power broom, or as directed.

On those types of bases where a prime coat is required and specified, the prime shall be applied and satisfactorily cured before starting the bituminous surface treatment.

When specified the contractor will be required to patch, with premixed material, any holes or other malformations deviating from the true cross section and grade. The premixed material shall be made of the bituminous material specified in the proposal or plans, prepared by the method as directed by the engineer. All small patches shall be thoroughly hand-tamped while the large patches shall be rolled with a power or pneumatic roller.

609-3.5 FIRST APPLICATION OF BITUMINOUS MATERIAL AND AGGREGATE MATERIAL. Upon the properly prepared surface, as hereinbefore specified, bituminous material shall be so applied at the rate and temperature specified by means of a pressure distributor so that a uniform distribution is obtained at all points. Application of the bituminous material shall be made in strips of a minimum width of ten (10) feet. Strips shall not exceed two thousand (2,000) feet in length before adjacent strips are placed. To insure proper drainage, the strips shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope. During all applications, the surfaces of adjacent structures shall be protected in such manner as to prevent their being spattered or marred. Bituminous material shall not be discharged into borrow pits or gutters or upon the airport area.

Within thirty (30) minutes after the application of the bituminous material, No. 7 cover aggregate at the rate specified shall be spread uniformly over the bituminous material with the aggregate equipment specified. Trucks spreading aggregate shall be operated backward so that the bituminous material will be covered before the truck wheels pass over it. The aggregate shall be spread in the same width of application as for the bituminous material, and shall not be applied in such thickness as to cause blanketing. Back-spotting or sprinkling of additional aggregate material, and pouring additional bituminous material over areas that show up having insufficient cover or bitumen, shall be done by hand whenever necessary. Additional spreading of aggregate material shall be done by means of a motor-patrol grader equipped with broom mould-board, a broom drag, or a power broom, as directed by the engineer.

Rolling by means of power and pneumatic rollers shall be started as soon as sufficient aggregate is spread to prevent pick-up. The rolling shall be continued until no more aggregate material can be worked into the surface. Blading with the wire-broom mould-board attachment or broom-dragging shall start as soon as possible after the rolling has started and after the surface has set sufficiently to prevent excessive marking. Further blading with the broom mould-board or broom-dragging and rolling on the strip being placed, and on adjacent strips previously placed, shall be done as often as necessary to keep the aggregate material uniformly distributed. These operations shall be continued until the surface is evenly covered and cured to the satisfaction of the engineer.

When the surface treatment is placed on a keystone mat, the bituminous material application shall be split in approximate equal amounts, one-half spread before the aggregate material and one-half on top of the aggregate. After the second portion is spread, the surface shall be well-dragged before rolling. The size of aggregate used in this case shall be the No. 8 gradation.

609-3.6 SEAL COAT APPLICATION. The seal coat shall be applied after a period of forty-eight (48) hours, but within five (5) days after first applications of bituminous materials and aggregate, unless delayed by bad weather conditions. The seal coat shall be applied in accordance with the requirements of Item P-604, except when the engineer or the proposal permits the use of sand as cover material. The sand shall meet the quality requirements of this specification and all other applicable requirements of Item P-604. If dust, dirt, or other foreign matter accumulates on the surface between the first application and the seal coat application, the contractor will be required to sweep and clean the surface as specified herein. Upon the clean and properly cured surface of the first application of bituminous material and aggregate, the bituminous material and the cover aggregate of the seal coat shall be spread and handled as required. Extreme care shall be taken in all applications to avoid brooming or tracking dirt or any foreign matter at any time or on any portion of the pavement surface under construction.

All surplus cover aggregate shall be swept off the surface and removed prior to final acceptance of the work.

609-3.7 CORRECTION OF DEFECTS. Any defects, such as raveling, low centers, lack of uniformity, or other imperfections caused by faulty workmanship, shall be corrected to the satisfaction of the engineer, and new work shall not be opened until such defects have been remedied.

All improper workmanship and defective materials resulting from over-heating, improper handling, or application shall be removed by the contractor and replaced with approved materials and workmanship as provided for in these specifications.

609-3.8 MAINTENANCE. The contractor, for a period of five (5) days after the completion of all work on any pavement section as the work progresses daily, shall maintain the completed

pavement, adding cover aggregate material where surplus bituminous material may appear on the surface due to action of traffic or climatic conditions. These pavement sections shall be rolled as directed with a pneumatic roller for at least ten (10) hours daily during this period.

In the event of the contractor's failure or neglect to faithfully perform this maintenance, resulting in injury to the surface, the contractor, at his own expense, shall make the necessary repairs to the satisfaction of the engineer.

The surface shall be maintained by the contractor until the final acceptance of the surfacing. Suitable precautions shall be taken by the contractor to protect the surface and prevent the tracking of dirt or any foreign material onto the surface.

609-3.9 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous materials that the contractor proposes to use, together with a statement as to their source and character, must be submitted and approval obtained before use of such materials begins.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of bitumen shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

609-3.10 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the contractor shall file with the engineer receipted bills where railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous and covering materials actually used in the construction covered by the contract. The contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken by the engineer, nor shall the car or tank be released until the final outage has been taken by the engineer.

Copies of all freight bills and weigh bills shall be furnished to the engineer during the progress of the work.

METHOD OF MEASUREMENT

609-4.1 The unit of measurement for bituminous material shall be the gallon or the ton. The gallonage or tonnage to be paid for shall be the number of gallons or tons of bituminous material used as ordered for the accepted work. Gallonage shall be determined by measuring the material at a temperature of 60° F., or by converting the gallonage measured at other temperatures to gallonage at 60° F., in accordance with A. S. T. M. Designation D-206, using

the table titled Group O for asphalts, and in accordance with an appropriate formula for emulsified asphalt.

609-4.2 The tonnage of either No. 7 or No. 8 aggregate material to be paid for shall be the number of tons of aggregate used as ordered for the accepted work.

609-4.3 The tonnage of seal-coat cover aggregate to be paid for shall be the number of tons of cover aggregate used as ordered for the accepted work or placed in authorized stock piles.

BASIS OF PAYMENT

609-5.1 The quantities of bituminous material, cover aggregate, and seal-coat aggregate, determined as provided above, shall be paid for at the respective contract unit prices bid per gallon or per ton for bituminous material, and per ton for cover aggregate, and per ton for seal-coat aggregate, which prices and payments shall constitute full compensation for furnishing, loading, hauling, and application of all materials; for spreading, brooming, and compacting; for reconditioning, preparing, sweeping, and patching the underlying course; for reconstruction and correction of defects; for maintenance; for any required construction, repair, and obliteration of access roads; for making arrangements, acquiring property or royalties for the operation of pits or quarries; for all pit or quarry moves; for clearing, stripping, drainage, and clean-up of pits or quarries; for the handling and disposal of unsuitable materials encountered in pit or quarry operations; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item P-609-5.1 Bituminous Material—per gallon or per ton.

Item P-609-5.1 Surface Treatment Aggregate—per ton.

Item P-609-5.1 Cover Aggregate—per ton.

ITEM P-610 STRUCTURAL PORTLAND CEMENT CONCRETE

(Plain and Reinforced)

DESCRIPTION

610-1.1 This item shall consist of either plain or reinforced structural Portland cement concrete, prepared and constructed in accordance with these specifications, at the locations and of the form and dimensions shown on the plans. The concrete shall be composed of coarse aggregate, fine aggregate, Portland cement, and water.

MATERIALS

610-2.1 GENERAL. Only approved materials, conforming to the requirements of these specifications, shall be used in the work. They may be subjected to inspection and tests at any time during the progress of their preparation or use. The source of supply of each of the materials shall be approved by the engineer before delivery or use is started. Representative preliminary samples of the materials shall be submitted by the contractor, when required, for examination and test. Materials shall be stored and handled so as to insure the preservation of their quality and fitness for use, and shall be located so as to facilitate prompt inspection. All equipment for handling and transporting materials and concrete must be clean before any material or concrete are placed therein. All testing and sampling shall be done in accordance with the specifications of the A. A. S. H. O., except when otherwise provided.

In no case will the use of pit-run or naturally mixed aggregates be permitted. Naturally mixed aggregate must in every case be screened and washed, and all fine and coarse aggregates must be stored separately and shall be kept clean. The mixing of different kinds of aggregates from different sources in one storage pile or alternating batches of different aggregates will not be permitted. Aggregates containing lumps of frozen or partially cemented material shall not be used.

610-2.2 COARSE AGGREGATE. The coarse aggregate for concrete shall meet the requirements of A. A. S. H. O. Specifications M-80. The percentage of wear (Los Angeles Rattler Test) shall not be more than fifty (50).

The coarse aggregate shall not have more than one (1) percent of material removed by the decantation test, using A. A. S. H. O. Method

T-11; nor more than one (1) percent of shale, using A. A. S. H. O. Method T-10; nor more than five (5) percent of soft fragments; nor more than one-fourth ($\frac{1}{4}$) percent of clay lumps. The total of shale, coal, clay lumps, and soft fragments shall not be more than five (5) percent.

TABLE 1.—*Requirements for Gradation of Coarse Aggregate*

Sieve designation	Percentage by weight passing square mesh sieves (A. A. S. H. O. T-27)						No. 4
	2"	1½"	1"	¾"	½"	⅜"	
No. 4 to ¾-inch	-----	-----	100	90-100	-----	20-55	0-10
No. 4 to 1-inch	-----	100	90-100	-----	25-60	-----	0-10
No. 4 to 1½-inch	100	95-100	-----	35- 70	-----	10-30	0- 5

The size of the coarse aggregate shall be as designated in the proposal, or as shown on the plans, and in accordance to whether the concrete is reinforced or plain. Coarse aggregate shall be well graded from coarse to fine so that concrete of the required workability, density, and strength can be made without the use of excessive amount of sand, water, or cement.

Different types of coarse aggregate shall not be mixed or used alternately in any one structure.

610-2.3 FINE AGGREGATE. The fine aggregate for concrete shall meet the requirements of A. A. S. H. O. Specification M-6.

When subjected to five (5) cycles of the sodium sulphate soundness test, the fine aggregate shall have a total loss not greater than ten (10) percent by weight. Instead of the soundness test mentioned above, the contractor may provide evidence, satisfactory to the engineer, that the fine aggregate has been exposed to natural weathering, either directly or in concrete, for a period of at least five (5) years without appreciable disintegration.

Fine aggregate shall contain not more than three (3) percent of material removable by a decantation test using A. A. S. H. O. Method T-11, nor more than one (1) percent of clay lumps; or one (1) percent of shale, as determined by A. A. S. H. O. Method T-10. The total of coal, clay lumps, shale, soft fragments, and other local deleterious substances shall not be more than five (5) percent.

The percentage of clay lumps shall be determined by examining the various fractions that remain after the material has been tested for grading. Any particles that can be broken up with the fingers shall be classified as clay lumps, and the total percentage by weight of all clay lumps shall be determined on the basis of the total original weight of the sample.

The fine aggregate shall be well graded from fine to coarse, and shall meet the following grading requirements, using A. A. S. H. O. Method T-27:

TABLE 2.—Requirements for Gradation of Fine Aggregate

Sieve designation	Percentage by weight passing square mesh sieves
$\frac{3}{8}$ -inch.....	100
No. 4.....	95-100
No. 16.....	45- 80
No. 30.....	25- 55
No. 50.....	10- 30
No. 100.....	2- 10

Blending will be permitted, if necessary, in order to meet the gradation requirements for fine aggregate. Fine aggregate deficient in the percentage of material passing the No. 50 mesh sieve may be accepted, provided that such deficiency does not exceed five (5) percent and is remedied by the addition of puzzolanic or cementitious materials other than Portland cement, as specified in paragraph on admixtures, in sufficient quantity to produce the required workability as approved by the engineer.

610-2.4 CEMENT. The cement used in the work shall be a standard brand of Portland cement, a standard brand of high-early-strength Portland cement, or a standard brand of moderate sulphate-resisting cement. Portland cement shall conform to A. S. T. M. Designation C-150. Only one brand of each shall be used on any one job, except by specific written permission from the engineer. The contractor shall provide suitable means for storing cement and protecting it from dampness. Different grades of cement shall be stored separately, and shall not be mixed.

The cement shall be delivered in canvas bags or other strong, well-made packages, except when the use of bulk cement is approved. Bags of cement in which, for any reason, the cement has become partially set, or which contain lumps of caked cement, shall be rejected. Use of cement salvaged from discarded or used bags will not be permitted.

Where bulk cement is allowed, the batching equipment shall include a screen of such size and construction in the loading chute as will insure against the presence of burlap, paper, and other foreign materials in the concrete, and a canvas "boot" or a similar device which will prevent wastage or loss from air currents. This screen shall be cleaned at least once daily; more frequently if conditions justify. Measurement of bulk cement shall be by weight. When-

ever bulk cement is hauled, it shall be transported in suitable weather-tight trucks.

Where so indicated on the plans, high-early-strength Portland cement shall be used instead of Portland cement. When high-early-strength cement is used, concreting operations shall not be carried on if the atmospheric temperature is below or may be expected to drop below 50° F., except upon written authorization from the engineer. All provisions of these specifications, except the cement, shall be applicable to such concrete. If the contractor, in order to facilitate his own operations, chooses to use high-early-strength cement in portions of the work other than those where its use is required, written permission must be obtained from the engineer.

Natural cement may be used with Portland cement at the ratio of one bag of natural cement to five bags of Portland cement. Natural cement shall conform with the requirements of A. S. T. M. Designation C-10, except that the use of a grinding aid will be mandatory. An 85-pound bag of natural cement will be accepted for replacing a 94-pound bag of Portland cement. The natural cement shall be made water repellent by the use of grinding aid composed of one-tenth (0.1) to two-tenths (0.2) percent paraffine in a carrier of oil or petroleum distillate not to exceed eight-tenths (0.8) percent by weight. In lieu thereof, the manufacturer may use from one-tenth (0.1) to two-tenths (0.2) percent tallow or fatty acid. Natural cement may be used up to seventeen (17) percent by weight. Natural cement shall be blended with standard Portland cement that contains no admixtures for air entrainment.

The contractor shall furnish vendor's certified test report for each carload, or equivalent, of cement shipped to the project. The report shall be delivered to the engineer before permission is granted for use of the cement. All such test reports shall be subject to verification by testing of samples of materials as received for use on the project.

610-2.5 WATER. The water used in concrete shall be free from sewage, oil, acid, strong alkalis or vegetable matter, and also shall be free from clay and loam. If the water is of questionable quality, it shall be tested in accordance with A. A. S. H. O. Method T-26.

610-2.6 MATERIAL ADDED FOR WORKABILITY. The use of any material added to the mix to improve workability which, in the opinion of the engineer, may have an injurious effect on the strength, density, and durability of the concrete will not be permitted. Before approval of any material, the contractor will be required to submit the results of complete chemical and sieve analyses made by an acceptable testing laboratory. Subsequent tests will be made of samples taken by the engineer from the supply of the material being used on the work to determine whether it is uniform in quality with that approved.

The material added shall be pozzuolanic, cementitious, or silicious. It shall not contain effective early-heat-producing elements, nor com-

pounds such as those contained in Portland cement, nor shall its use result in a material increase in the free-lime content of the concrete. It also shall be in conformity with the following requirements:

Free moisture—A total of not more than three (3) percent by weight.

Passing No. 30 sieve—Not less than one hundred (100) percent by weight.

Passing No. 200 sieve—Not less than eighty-five (85) percent by weight.

610-2.7 PREMOULDED JOINT MATERIAL. Premoulded joint material for expansion joints shall meet the requirements of one of the following A. A. S. H. O. Specifications: M-33, M-58, or M-59.

610-2.8 JOINT FILLER. The filler for joints shall meet the requirements of A. A. S. H. O. Specification M-18 grade A or B, or Item P-605, unless otherwise specified in the proposal.

610-2.9 STEEL REINFORCEMENT. Concrete reinforcement bars shall meet the requirements of A. A. S. H. O. Specification M-31. Welded wire fabric for concrete reinforcement shall conform to the requirements of A. A. S. H. O. Specification M-55. Reinforcing bars shall be of the grade and either plain or deformed, as indicated on the plans or as called for in the proposal. All bars shall be the full weight called for according to size.

610-2.10 CALCIUM CHLORIDE. When calcium chloride is permitted by the engineer as an admixture in the concrete as an accelerator, it shall meet the requirements of A. S. T. M. Designation D-98.

CONSTRUCTION METHODS

610-3.1 GENERAL. The contractor shall furnish all labor, materials, and services necessary for, and incidental to, the completion of all work as shown on the drawings and herein specified. All machinery and equipment owned or controlled by the contractor, which is proposed to be employed by him on the work, shall be of sufficient size to meet the requirements of the work, and shall be such as to produce a satisfactory quality of work; all to be subject to the inspection and approval of the engineer. The contractor shall employ, at all times, a sufficient force of workmen of such experience and ability that the work can be prosecuted in a satisfactory and workmanlike manner.

610-3.2 CONCRETE PROPORTIONS. The concrete shall consist of a mixture of coarse aggregate, fine aggregate, Portland cement, and water. All aggregates and bulk cement shall be measured by weight. In proportioning aggregates and mixing water, compensation shall be made for the weight of moisture in the aggregates which shall be determined periodically.

When package cement is used, the calculated quantities for each batch shall be exactly equal to one or more whole sacks of cement.

Each bag shall contain ninety-four (94) pounds net and shall be considered equal to one (1) cubic foot.

CLASS A CONCRETE

(Materials for One (1) Cubic Yard of Concrete)

Type of coarse aggregate	Minimum cement content	Maximum net water content <i>Gallons</i>	Weights in pounds dry aggregate		Slump range <i>Inches</i>
			Fine aggregate	Total aggregate	
Gravel.....	6 bags.....	35	1070-1190	3210	2-5
Crushed stone.....	6 bags.....	38	1220-1360	3200	2-5
Slag.....	6 bags.....	38	1330-1470	2930	2-5

The proportions in the above table are based on the use of well-graded aggregates. If it is found impossible with the aggregates selected to prepare concrete of the proper consistency without exceeding the maximum net water content specified, the total weight of aggregate shall be reduced by the engineer until concrete of the proper consistency is obtained without exceeding the maximum net water content specified. However, the contractor shall not be compensated for any additional cement which may be required by reason of such adjustment.

The weights specified in the above table were calculated for aggregates of the following bulk specific gravities: Natural sand and gravel, 2.65; crushed stone, 2.70; slag, 2.30. For aggregates of specific gravities differing more than ± 0.02 from those given above, the weights given in the tables shall be corrected. The quantities shown for cement and water shall control, and the weights of aggregates shall be varied to secure the proper yield based on absolute volumes. When a special mix requiring a reduction in the amount of water is desired, the quantities of aggregate shall be increased to maintain the specified yield.

610-3.3 CONTROL TESTS. When directed by the engineer, the contractor shall make test cylinders and/or beams from the concrete as mixed for the work as herein specified.

Concrete test specimen shall be made in accordance with the standard method of "Making and Storing Compression Test Specimens of Concrete in the Field" of A. A. S. H. O. Method T-23; also with the standard method of "Flexural Strength of Concrete" of A. A. S. H. O. Method T-97 with respect to moulding specimen only. The contractor shall cure and store the test specimens under such conditions as directed. The engineer will make the actual tests on the test specimen at no expense to the contractor.

When directed, the contractor shall make yield test of the concrete mix. This test shall be made in accordance with A. A. S. H. O. Method T-121.

610-3.4 PROPORTIONING AND MEASURING DEVICES.

When package cement is used, the quantity for each batch shall be exactly equal to one or more whole sacks of cement. The aggregates shall be measured separately by weight. If aggregates are delivered to the mixer in batch trucks, the exact amount for each mixer charge shall be contained in each batch compartment. Weighing boxes or hoppers shall be approved by the engineer, and shall provide positive means of regulating the flow of aggregates into the batch box so that the required and exact weight of aggregates can be readily obtained. An approved method of accurate weighing shall be used to insure positive control of the required amounts of aggregates.

610-3.5 CONSISTENCY. The consistency of the concrete shall be checked by the slump test, as described in "Slump Test for Consistency of Portland Cement Concrete," A. A. S. H. O. Method T-119. Each concrete mixer shall be equipped with a standard slump cone which shall be used to check the consistency. The maximum slump shall not exceed five (5) inches.

610-3.6 MIXING. All equipment necessary for the mixing and placing of the concrete shall be on the site of construction and approved before concreting operations are begun.

All concrete shall be thoroughly mixed in a batch mixer of an approved size and type so designed as to insure uniform and thorough distribution of the materials throughout the mix. All concrete shall be mixed for a period of not less than one (1) minute after all materials, including the mixing water, have been placed in the mixer. The entire contents of the mixer shall be removed from the drum before the materials for the succeeding batch are placed therein. The mixer shall be equipped with an approved timing device and automatic water-measuring device. The volume of materials mixed per batch shall not exceed the manufacturer's stated capacity of the drum.

610-3.7 READY MIX. When ready-mixed concrete is used, the materials, proportioning, mixing, and consistency shall meet these specifications. There shall be sufficient plant capacity and transportation facilities available to insure delivery of concrete at the rate required. The concrete shall be delivered and placed within one (1) hour after the cement is placed in contact with damp aggregate or water.

(a) *Central Mix.* The central mixer shall be approved and shall produce satisfactory concrete. The concrete shall be delivered in a watertight agitator truck or truck mixer that will protect the concrete from rain, freezing, drying out, segregating, or from becoming affected in any manner.

(b) *Truck Mixer.* The truck mixer shall consist of suitable equipment for combining aggregates, cement, and water into a thoroughly mixed and uniform concrete of a quality meeting all the requirements herein. The mixer shall have a revolution counter for timing the mixing, and a water measuring device. Wash water

shall not be used in any concrete mix. This type of mixing equipment shall produce concrete of the proper consistency, or its use shall be prohibited.

610-3.8 MIXING CONDITIONS. The concrete shall be mixed only in such quantities as are required for immediate use. No concrete shall be mixed while the air temperature is below 40° F. without permission of the engineer. If permission is granted for mixing under such conditions, aggregates or water, or both, shall be heated and the concrete shall be placed at a temperature of not less than 50° F. nor more than 100° F. The contractor shall be held responsible for any defective work resulting from freezing or injury in any manner during placing and curing, and shall replace such work at his expense.

Retempering of concrete by adding water or any other material shall not be permitted.

The delivery of concrete to the job shall be in such a manner that batches of concrete will be deposited at uninterrupted intervals.

610-3.9 FORMS. Concrete shall not be placed until all the forms and reinforcement have been inspected and approved by the engineer. Forms shall be of suitable material and shall be of the type, size, shape, quality, and strength to build the structure as designed on the plans. The forms shall be true to line and grade, shall be mortar-tight, and sufficiently rigid to prevent displacement and sagging between supports. The responsibility for their adequacy shall rest with the contractor. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes. The internal ties shall be so arranged that, when the forms are removed, no metal will show in the concrete surface, or discolor the surface when exposed to weathering. All forms shall be wetted with water or with a nonstaining mineral oil which shall be applied shortly before the concrete is placed. Forms shall be constructed so that they can be removed without injuring the concrete or concrete surface. The forms shall not be removed before the expiration of at least thirty (30) hours from vertical faces, walls, slender columns, and similar structures; forms supported by falsework under slabs, beams, girders, arches, and similar construction shall not be removed until tests indicate at least sixty (60) percent of the design strength of the concrete has developed, as approved by the engineer.

610-3.10 PLACING REINFORCEMENT. All reinforcement shall be accurately placed, as shown on the plans, and shall be firmly held in position during concreting. Bars shall be fastened together at intersections. The reinforcement shall be supported by approved metal chairs. Shop drawings, lists, and bending details shall be supplied by the contractor when required.

610-3.11 EMBEDDED ITEMS. Before placing concrete, any items that are to be embedded shall be firmly and securely fastened in place as indicated. All such items shall be thoroughly clean and free from coating, rust, scale, oil, or any foreign matter. The embedding

of wood shall be avoided. Around and against embedded items the concrete shall be spaded and consolidated.

610-3.12 PLACING CONCRETE. All concrete shall be placed during the daylight unless otherwise approved. The concrete shall not be placed until the depth and character of foundation, the adequacy of forms and falsework, and the placing of the steel reinforcing have been approved. Concrete shall be placed as soon as practical after mixing, and in no case shall concrete be used which cannot be placed within one (1) hour after water is added to the mix. The method and manner of placing shall be such as to avoid segregation and displacement of the reinforcement. Troughs, pipes, and chutes shall be used as aid in placing concrete when necessary. Dropping the concrete a distance of more than five (5) feet, or depositing a large quantity at one point, will not be permitted. All concrete shall be placed in the dry upon clean, damp surfaces, free from running water, or upon properly consolidated soil, but never upon soft mud or dry porous earth. Care shall be exercised in dropping concrete through reinforcement so that no segregation of the coarse aggregate, nor displacement of the reinforcement, occurs. Concrete shall be deposited in approximately horizontal layers of not more than two (2) feet. Concrete shall be deposited as near final position as possible. Concrete shall be compacted and spaded by suitable hand tools to work the coarse aggregate back from the face of the forms, to force the concrete under and around the reinforcement and on exposed faces to secure smooth, dense, and even surfaces. With permission of the engineer, approved mechanical devices for vibrating the concrete can be used, but the vibrations shall be applied to the concrete direct and not through the forms or the reinforcement. When concrete is placed in water a satisfactory tremie method shall be used.

610-3.13 CONSTRUCTION JOINTS. When the placing of concrete is suspended, necessary provisions shall be made for joining future work before the placed concrete takes its initial set. For the proper bonding of old and new concrete, such provisions shall be made for grooves, steps, keys, dovetails, reinforcing bars or other devices as may be prescribed. The work shall be arranged that a section begun on any day shall be finished by daylight on the same day. Before depositing new concrete on or against concrete which has hardened, the surface of the hardened concrete shall be cleaned by a heavy steel broom, roughened slightly, wetted, and covered with a coating of neat cement paste or grout.

610-3.14 EXPANSION JOINTS. Expansion joints shall be constructed at such points and of such dimensions as may be indicated on the drawings. The premoulded filler shall be cut to the same shape as that of the surfaces being joined. Along all edges that will be exposed in the finished work the filler shall be cut one-fourth inch smaller. The filler shall be fixed firmly against the surface of the concrete already in place in such a manner that it will not be displaced when concrete is deposited against it.

610-3.15 CLEANING FORMS AND EQUIPMENT. Before placing concrete all equipment for mixing, transporting, and placing the concrete shall be cleaned, and debris, dirt, or other objectional substances shall be removed from the places to be occupied by the concrete. The inside of the forms shall be thoroughly cleaned and wetted, except in freezing weather. Reinforcement shall be cleaned of rust or other coatings. If concreting is permitted in cold weather, the forms shall be coated with nonstaining mineral oil.

610-3.16 DEFECTIVE WORK. Any defective work disclosed after the forms have been removed shall be immediately removed and replaced. If any dimensions are deficient, or if the surface of the concrete is bulged, uneven, or shows honey comb, which in the opinion of the engineer cannot be repaired satisfactorily, the entire section shall be removed and replaced at the expense of the contractor.

610-3.17 SURFACE FINISH. All exposed concrete surfaces shall be true, smooth, free from open or rough spaces, depressions, or projections. The concrete in horizontal plane surfaces shall be brought flush with the finished top surface at the proper elevation, and shall be struck off with a straightedge and floated. Mortar finishing shall not be permitted, nor shall dry cement or sand-cement mixture be spread over the concrete during the finishing of horizontal plane surfaces.

When directed, the surface finish of exposed concrete shall be a rubbed finish. If forms can be removed while the concrete is still green, the surface shall be pointed and wetted and then rubbed with a wooden float until all irregularities are removed. If the concrete has hardened before being rubbed, a carborundum stone shall be used to finish the surface. When approved, the finishing can be done with a rubbing machine.

610-3.18 CURING AND PROTECTION. All concrete and cement work shall be properly cured and protected by the contractor. The work shall be protected from the elements, flowing water, and from defacement of any nature during the building operations.

The concrete or cement work shall be protected and cured as soon as it hardens sufficiently by covering with burlap, cotton, or jute felt mats, clean sand, nonstaining sawdust, paper blankets, or similar approved material. The water absorptive covering shall be thoroughly saturated when placed, and kept saturated for a period of at least three (3) days. All curing mats or blankets shall be sufficiently weighted or tied down to keep the concrete surface covered and prevent the surface from being exposed to currents of air. Where wooden forms are used they shall be kept wet at all times until removed to prevent the opening of joints and drying out of the concrete. Traffic shall not be allowed on concrete surfaces for a period of seven (7) days after the concrete has been placed.

610-3.19 DRAINS OR DUCTS. Drainage pipes, conduits, and ducts that are to be encased in concrete shall be installed by the contractor before the concrete is placed. The pipe shall be held rigidly

so that it will not be displaced or moved during the placing of the concrete.

610-3.20 COLD WEATHER PROTECTION. When concrete is placed at temperatures below 40° F., the contractor shall provide satisfactory methods and means to protect the mix from injury by freezing. The aggregates, or water, or both, shall be heated in order to place the concrete at temperatures between 50° F. and 100° F. Placing of concrete may be started in the morning, if the contractor desires, but shall be discontinued at 3 p. m. of the same day if freezing weather threatens. The concrete or aggregates shall be protected during transit, mixing, and before and after placing, as directed by the engineer, to retain all heat possible in the concrete mix. After the concrete has been placed the contractor shall provide sufficient protection such as cover, canvas, framework, heating apparatus, etc., to enclose and protect the structure and maintain the temperature of the mix at not less than 50° F. until at least sixty (60) percent of the designed strength has been attained.

610-3.21 FILLING JOINTS. All joints which require filling shall be thoroughly cleaned, and any excess mortar or concrete cut out with proper tools. Joint filling shall not be started until after final curing, and shall be done only when the concrete is completely dry. The cleaning and filling shall be carefully done with proper equipment and in a manner to obtain a neat looking joint free from excess and unsightly filler.

METHOD OF MEASUREMENT

610-4.1 The yardage of Portland cement concrete to be paid for shall be the number of cubic yards of concrete complete in place and accepted. In computing the yardage of concrete for payment, the dimensions used shall be those shown on the plans or ordered by the engineer. No measurements or other allowances will be made for forms, false work, cofferdams, pumping, bracing, expansion joints, or finishing of the concrete. No deductions in yardage will be made for the volumes of reinforcing steel or embedded items.

610-4.2 The poundage of reinforcing steel to be paid for shall be the calculated theoretical number of pounds placed as shown on the plans, complete in place and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars, as the case may be, of equal nominal size. If so indicated on the plans, the poundage to be paid for shall include the weight of metal pipes and drains, metal conduits and ducts, or similar materials indicated and included.

BASIS OF PAYMENT

610-5.1 The yardage of Portland cement concrete and poundage of reinforcing steel, determined as provided in 4.1 and 4.2 above, shall be paid for at the contract unit price per cubic yard for concrete and per pound for reinforcing steel, as called for in the bid schedules,

which prices and payment shall constitute full compensation for the concrete; for the reinforcing steel; for furnishing all materials; for placing and finishing; for furnishing and installing all joints, joint fillers, drains, ducts, etc.; for forms and false work; for curing and protection; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-610-5.1 Structural Portland Cement Concrete—per cubic yard.

Item P-610-5.1 Steel Reinforcement—per pound.

ITEM P-612 ADMIXTURES

DESCRIPTION

612-1.1 The work shall consist of incorporating and blending or mixing an admixture with the type of subgrade, subbase, base, or surface course specified or as designated by the engineer.

The methods of incorporation shall be governed by the type of admixture used and by the type of course to which it is added.

MATERIALS

612-2.1 ADMIXTURE. The admixture used shall meet the following requirements:

The flaked calcium chloride shall conform to the requirements of the A. S. T. M. Designation D-98. The rate of application of calcium chloride shall be between one-half ($\frac{1}{2}$) percent and one and one-half ($1\frac{1}{2}$) percent by weight.

The stabinol shall be a resinous compound of uniform composition, and capable of waterproofing soil and soil blends. The material shall be in powdered form and be easy to handle and to distribute. The rate of application of stabinol shall be between one-half ($\frac{1}{2}$) percent and one and one-half ($1\frac{1}{2}$) percent by weight.

The admixture shall be in a loose condition, and not caked or solidified, so that it cannot be readily spread by equipment intended for that purpose.

612-2.2 SOILS, SOIL BLENDS OR AGGREGATES. The soils, soil blends, or the aggregates which compose the subgrades, subbases, bases, or surface courses with which the admixture is to be mixed shall be designated in the proposal, by other specifications, or by the engineer.

The requirements of these materials will be included in other specifications, or the materials shall be as they exist in the natural condition either before or after grading operations.

CONSTRUCTION METHODS

612-3.1 WEATHER LIMITATIONS. The placing of admixtures and operations thereof shall be carried on only when the weather is suitable, when the surface is not wet or saturated, and when the atmospheric temperature is above 40° F. These requirements shall not be waived, unless directed by the engineer.

612-3.2 EQUIPMENT. Before the work is started all methods, equipment, tools, plants, and machinery employed or used in executing any part of this work shall be subject to the approval of the engineer. Items found unsatisfactory shall be changed or improved as required. All equipment, tools, machinery, and plant used must be maintained in a satisfactory working condition.

Road machines shall weigh not less than three (3) tons, shall have a wheel base not less than fifteen (15) feet and a blade not less than ten (10) feet. Road machines shall not be pulled with rollers. Motor patrols weighing not less than six (6) tons, with ten (10) foot minimum blades may be used in lieu of road machines.

Provision shall be made by the contractor for furnishing water at the plant or at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

The mechanical spreader, when required for distribution of the admixture, shall be equipment similar to a chip-spreader, a lime-spreader, or similar approved device which will place the admixture uniformly and at the rate directed. The range of application shall be from one-half ($\frac{1}{2}$) to five (5) pounds per square yard.

If an admixture is to be incorporated and mixed with a material that is being processed or mixed by a central processing plant or a travel plant, such equipment shall be capable of storing, handling, measuring, and placing the admixture in the manner and quantity specified and as required.

The mixing equipment shall be designed, constructed, operated, and of the capacity so as to thoroughly incorporate the admixture with the materials.

For in-place mixing this equipment may consist of a rotary tiller or a mixing unit which combines pulverizing, blending, liquid application, and complete mixing with a single pass. Other types of mixing equipment can be used when the intended incorporation and mixing is obtained, and when approved by the engineer.

612-3.3 CENTRAL OR TRAVEL PLANT MIXING. When any material in which the admixture is to be incorporated is being processed or mixed in a central or travel plant, the admixture shall be measured and placed with the material prior to mixing. In the mixing process the admixture shall be thoroughly blended and mixed with the material. The kind and amount of admixture added shall be as given in the proposal. The moisture content of the material at the time of processing shall be such as to permit complete dispersement. After the processing, the material shall be placed, spread, and compacted as the material specification requires. The treated material shall be placed, spread, and compacted within a definite period of time when there is some reaction due to the presence of the admixture, when there is any loss in the quantity or quality of the admixture, or when there is likely to be a loss or gain in the moisture content.

612-3.4 PREPARING THE COURSE. The course in-place that is to be treated shall be spread to the proper thickness, grade,

and contour, and approved by the engineer. If the material is or has become compacted, it shall be scarified as directed to a uniform specified depth. Any depressions or high places shall be reshaped. The material shall be at the moisture content, as directed by the engineer, or brought to that content either by adding water or by aeration to permit the thorough mixing of the admixture.

612-3.5 SPREADING. When the admixture is handled in flake or powder form, it shall be spread by a suitable mechanical spreader. The spreader shall apply the admixture at a uniform and prescribed rate given in the proposal.

612-3.6 MIXING. When required to mix the admixture for a specified depth of three (3) inches or more, the mixing shall be accomplished by the required equipment, such as a rotary-tiller or similar approved equipment. The total surface area shall be covered by the mixer. The moisture content of the in-place material shall be such that complete distribution of the admixture is obtained.

When required to mix the admixture for a partial depth of two and one-half (2½) inches or less, the procedure shall be accomplished by pulverizing equipment, such as a harrow, disc, or similar approved apparatus. Care must be exercised that the admixture is not mixed below the desired depth.

Immediately after the admixture has been distributed, it shall be mixed with the in-place material to the depth required. Mixing shall be continued for as long a period and repeated as often as may be necessary to insure a uniform mixture throughout. The moisture content of the material shall be such as to secure complete dispersement. The treated material shall be struck off or bladed to a smooth surface and compacted within a designated period when directed by the engineer.

612-3.7 COMPACTION. After the mixing is complete, the course shall be compacted by rolling. The rolling shall be continued until the density of the material meets the density requirements as specified for the course. No payment shall be made under this item of admixture for compaction directly, but shall be considered as a subsidiary obligation under other items of the contract.

METHOD OF MEASUREMENT

612-4.1 The unit of measurement for the admixture shall be the pound or the ton, whichever is called for in the proposal, and which is used as ordered in the accepted work.

BASIS OF PAYMENT

612-5.1 The quantity of admixture, determined as provided above, shall be paid for at the contract unit price per pound or per ton in the bid schedule, which price and payment shall constitute full compensation for furnishing, delivering, and placing the admixture; for measuring, incorporating, and mixing when processed by plant

methods; for measuring, spreading, and mixing for in-place methods; for any blading or scarifying; and for all labor, equipment, tools, and incidentals necessary to complete the application.

The price and payment, stipulated above or elsewhere in the contract for other items of work, shall constitute full compensation for all watering, except that when the bid schedule contains an estimated quantity for watering of the course. Any authorized watering shall be paid for as provided.

Payment will be made under:

Item P-612-5.1 Admixtures—per pound or per ton.

DRAINAGE PIPE

ITEM D-701 CLAY PIPE FOR STORM SEWERS AND CULVERTS

DESCRIPTION

701-1.1 This item shall consist of vitrified clay pipe of the types, classes, sizes, and dimensions required on the plans, furnished and installed at such places as are designated on the plans and profiles, or by the engineer in accordance with these specifications and in conformity with the lines and grades given.

The item shall include in the bid price per linear foot of pipe in place, the cost of common excavation and backfill, the cost of furnishing and installing all trench bracing, all fittings required to complete the pipe drain as shown on the plans; and the material for and the making of all joints, including all connections to existing drainage pipes and structures.

MATERIALS

701-2.1 GENERAL. The pipe shall be of the type called for on the plans or in the proposal, and shall be in accordance with the following appropriate requirements. When the plans or the proposals permit a choice of pipe, the contractor shall indicate in the bid the type proposed to be furnished.

701-2.2 VITRIFIED CLAY PIPE. Vitrified clay pipe shall conform to the requirements of A. A. S. H. O. Specification M-65. Standard strength clay pipe may be used to provide drainage outside the airport boundary. Standard strength clay pipe shall be restricted to installations on Class 1 and 2 airports.

701-2.3 MORTAR. Mortar for pipe joints and connections to other drainage structures shall be composed of one part by volume of Portland cement and two parts of mortar sand. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. Hydrated lime may be added to the mixture of sand and cement in an amount equal to fifteen (15) percent of the weight of cement used.

701-2.4 CONCRETE. Concrete for pipe cradles shall conform to the requirements of Item P-610.

CONSTRUCTION METHODS

701-3.1 EQUIPMENT. All equipment necessary and required for the proper construction of storm sewers, and culverts shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The contractor shall provide hoisting equipment to handle the pipe in unloading and placing in its final position, without damage to the pipe.

The contractor shall provide such hand tampers and pneumatic tampers to obtain the compaction of the pipe bed and the backfill as specified.

701-3.2 EXCAVATION. (a) *Common.* The contractor shall do all common excavation to the depth shown on the plans. Common excavation shall consist of all excavation not included under rock excavation.

(b) *Rock.* The contractor shall do all rock excavation to the depth shown on plans plus at least four (4) inches. Rock excavation shall consist of the removal of boulders and detached rock, one-half ($\frac{1}{2}$) cubic yard in volume or greater, and of all rock in place in ledges or masses which can be removed only by the use of bars and sledges or by blasting.

When rock or noncushioning material is encountered in trench excavation, a cushion at least four (4) inches thick shall be placed between the rock and the bottom of the pipe. The cushion shall consist of clean sand or equivalent granular material. The cost of furnishing and placing the cushion material shall be included in the bid price per cubic yard for rock excavation. Before any rock is removed, the engineer shall have the opportunity to obtain the necessary data to determine the yardage to be used for payment. The bottom of the trench shall be excavated to a horizontal section as far as practicable.

(c) *General.* Excavated material not required or acceptable for backfill shall be disposed of by the contractor as directed by the engineer. Common excavation shall not be carried below the required depth; when this is done the trench shall be backfilled at the contractor's expense with material approved by the engineer and compacted to the density of the surrounding earth material as determined by the CAA compaction control tests T-611.

When directed, unstable soil shall be removed for the full width of the trench and replaced with sand or with approved granular material. The engineer shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe. When not specified in the special provisions, the cost of removing unstable soil and replacing it with approved material shall be covered by a supplemental agreement for the cubic yards of excavation and the cubic yards of approved material.

The depth of cut shown on the plans is from the surface grade to the invert of the pipe line. In case the depth of cut is changed from

that shown on the plans, the change shall not exceed six (6) inches without a revision in the contract unit price per linear foot of pipe. However, if the depth of cut is changed more than six (6) inches, compensation or deduction of work involved, whether increased or decreased, shall be provided for in a supplemental agreement.

The minimum width of the trench at the top of the pipe when placed shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the outside diameter of the pipe plus six (6) inches on each side of the pipe. The trench shall be excavated accurately to the established line so that at least a six (6) inch space will exist between the side of the trench and the side of the pipe. The sides of the trenches shall be vertical unless otherwise approved by the engineer. The maximum allowable width of trench shall not exceed twelve (12) inches on each side of the pipe when placed, unless otherwise approved by the engineer.

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Spaces for the pipe shall be excavated accurately to size to clear the bell so that the barrel supports the entire weight of the pipe.

The contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation; also, as required for safety and to conform to governing laws. Unless otherwise provided, the bracing, sheathing or shoring shall be removed by the contractor after the completion of the backfill to at least six (6) inches over the top of the pipe. The cost of the bracing, sheathing, or shoring and the removal of same shall be included in the unit price bid per foot for the pipe.

701-3.3 CRADLES. When the engineer finds the bottom of the trench to be an insufficient foundation for the pipe, he shall determine the locations and dimensions of the necessary cradles to properly support the pipe. The design details for the cradles shall be as shown on the plans.

701-3.4 LAYING AND INSTALLING PIPE. The contractor shall provide the necessary mason's lines and supports to insure installation of the pipe to line and grade as staked by the engineer. The contractor's facilities for lowering the pipe into the trench shall be such that neither the pipe nor the trench will be damaged or disturbed.

The engineer shall inspect all pipe before it is laid and reject any section that is damaged by handling or is found to be defective to a degree which will materially affect the function and service of the pipe.

The laying of the pipe in the finished trench shall be started at the lowest point and laid upgrade. The bells on bell and spigot pipe shall be laid upgrade.

The pipe shall be firmly and accurately set to line and grade so that the invert will be smooth and uniform. The pipe shall be protected from water during placing and until the mortar in the joints has thoroughly set.

360 701. CLAY PIPE FOR SEWERS AND CULVERTS

Pipe shall not be laid on frozen ground.

The upgrade end of pipe lines not terminating in a structure shall be plugged with a cap or plug approved by the engineer.

Pipe which is not true in alignment, or which shows any settlement after laying, shall be taken up and relaid without extra compensation.

701-3.5 MORTAR. Mortar shall be mixed in a ratio of one part by volume of Portland cement and two parts by volume of sand. The mortar shall be of the desired consistency for caulking and filling the joints of the pipe. Mortar that is not used within forty-five (45) minutes after water has been added, shall be discarded. Retempering of mortar will not be permitted.

701-3.6 PIPE JOINTS. Closed joints for storm sewers and culvert pipe shall be made as follows:

All pipe shall be carefully laid, bell end upgrade, spigot end fully entered into the adjacent bell, and true to lines and grades given.

The joints of the clay pipe shall be caulked and filled with the specified mortar.

Before succeeding sections of pipe are laid, the lower portions of the bell of the pipe shall be filled on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. After the pipe is laid, the remainder of the joints shall be solidly filled with mortar and sufficient additional mortar used to form a bead or ring around the outside of the joints. The inside of the joint shall be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap.

701-3.7 BACKFILLING. All trenches and excavations shall be backfilled in a reasonable time after the pipes are installed therein unless other protection of the pipe is directed by the engineer. The backfill material shall be approved by the engineer. Backfill material containing stones or rock exceeding three (3) inches in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds one (1) foot. Backfill material containing rock three (3) inches in diameter or larger shall not be used in trenches under paved areas. Special care shall be taken in placing the backfill. Great care shall be used to obtain thorough compaction under the haunches and along the sides to the top of the pipe.

The backfill shall be placed in loose layers not exceeding six (6) inches in depth under and around the pipe and not exceeding eight (8) inches over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the engineer, until the trench is completely filled and brought to the elevation as directed. Backfilling shall be done in such a manner as to avoid injurious top or side pressures on the pipe.

In embankments and for other areas outside of pavements, the backfill shall be compacted to the density as required for embankments in Item P-152 and determined by CAA compaction control tests T-611,

701. CLAY PIPE FOR SEWERS AND CULVERTS 361

for the class of airport involved. Under paved areas, the subgrade and any backfill up to a depth of five (5) feet below the subgrade shall be compacted to the same requirements as given for subgrades in Item P-152; below a depth of five (5) feet from the subgrade, the compaction shall be as stated for embankments.

701-3.8 CONNECTIONS. Where the plans call for connections to existing or proposed structures, these connections shall be watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

701-3.9 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work, described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the pipe.

701-3.10 INSPECTION. Prior to final approval of the drainage system the engineer, accompanied by the contractor's representative, shall make a thorough inspection, by an appropriate method, of the entire installation. Any indication of defects in material or workmanship or obstruction to flow in the pipe system shall be further investigated and corrected as necessary. Defects due to the contractor's negligence shall be corrected by the contractor without additional compensation, and as directed by the engineer.

METHOD OF MEASUREMENT

701-4.1 The footage of pipe to be paid for shall be the number of linear feet of pipe in place, completed and approved; measured along the centerline of the pipe from end or inside face of structure, to end or inside face of structure, whichever is applicable. The several classes, types, and sizes shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe line being measured.

701-4.2 The volume of concrete for pipe cradles to be paid for shall be the number of cubic yards of concrete complete in place and accepted; determined from the dimensions shown on the plans, or as ordered by the engineer.

701-4.3 Rock required to be removed shall be computed by the cubic yard for the specified width of the trench and to a depth of four (4) inches below the bed of the pipe. No payment will be made for the cushion material placed for the bed of the pipe.

BASIS OF PAYMENT

701-5.1 The footage of pipe as provided in Section 4.1 shall be paid for at the contract unit price per linear foot for "Vitrified Clay Pipe" of the several classes, types, and sizes, which price and payment shall constitute full compensation for furnishing, hauling, and installing the pipe; for common excavation; for backfill and compaction; for jointing; for connections to drainage structures; and for all material, labor, equipment, tools, and incidentals necessary to complete the drain as shown on the plans, but shall not constitute payment for manholes, catch basins, inlets, cradles, inspection holes or headwalls, the payment for which is provided for as separate items.

701-5.2 The cubic yards of concrete, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Concrete for Pipe Cradles," which price and payment shall constitute full compensation for concrete in place including reinforcing when shown on the plans.

701-5.3 The cubic yards of rock excavation, determined as provided in Section 4.3, shall be paid for at the contract unit price per cubic yard for "Rock Excavation," which price and payment shall constitute full compensation for excavation, placing cushion material, and disposal of material as defined.

Payment will be made under:

- Item D-701-5.1 ---- inch Standard Strength Clay Pipe—per linear foot.
- Item D-701-5.1 ---- inch Extra Strength Clay Pipe—per linear foot.
- Item D-701-5.2 Concrete for Pipe Cradles—per cubic yard.
- Item D-701-5.3 Rock Excavation—per cubic yard.

ITEM D-702 CONCRETE PIPE FOR STORM SEWERS AND CULVERTS

DESCRIPTION

702-1.1 This item shall consist of concrete pipe of the types, classes, sizes, and dimensions required on the plans, furnished and installed at such places as are designated on the plans and profiles, or by the engineer, in accordance with these specifications and in conformity with the lines and grades given.

The items shall include in the bid price per linear foot of pipe in place, the cost of common excavation, and backfill, the cost of furnishing and installing all trench bracing, all fittings required to complete the pipe drain as shown on the plans; and the material for and the making of all joints, including all connections to existing drainage pipes and structures.

MATERIALS

702-2.1 GENERAL. The pipe shall be of the type called for on the plans or in the proposal, and shall be in accordance with the following appropriate requirements. When the plans or the proposals permit a choice of pipe, the contractor shall indicate in the bid the type proposed to be furnished.

702-2.2 CONCRETE SEWER PIPE, STANDARD, NON-REINFORCED. Concrete sewer pipe, standard, non-reinforced, shall conform to the requirements of A. A. S. H. O. Specification M-86. Standard strength concrete sewer pipe may be used to provide drainage outside the airport boundary. Standard strength concrete sewer pipe shall be restricted to installation on Class 1 and 2 airports.

702-2.3 CONCRETE SEWER PIPE, STANDARD, REINFORCED. Concrete sewer pipe, standard, reinforced, shall conform to the requirements of A. A. S. H. O. Specification M-87.

702-2.4 CONCRETE CULVERT PIPE, STANDARD AND EXTRA STRENGTH, REINFORCED. Concrete culvert pipe, standard and extra strength, reinforced, shall conform to the requirements of A. A. S. H. O. Specification M-41.

702-2.5 MORTAR. Mortar for pipe joints and connections to other drainage structures shall be composed of one part by volume of Portland cement and two parts of mortar sand. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. Hydrated lime may be added to

364 702. CONCRETE PIPE FOR SEWERS AND CULVERTS

the mixture of sand and cement in an amount equal to fifteen (15) percent of the weight of cement used.

702-2.6 CONCRETE. Concrete for pipe cradles shall conform to the requirements of Item P-610.

CONSTRUCTION METHODS

702-3.1 EQUIPMENT. All equipment necessary and required for the proper construction of storm sewers, and culverts shall be on the project, in first-class working condition, and shall have been approved by the engineer before construction is permitted to start.

The contractor shall provide hoisting equipment to handle the pipe in unloading and placing in its final position, without damage to the pipe.

The contractor shall provide such hand tampers and pneumatic tampers to obtain the compaction of the pipe bed and the backfill as specified.

702-3.2 EXCAVATION. (a) *Common.* The contractor shall do all common excavation to the depth shown on the plans. Common excavation shall consist of all excavation not included under rock excavation.

(b) *Rock.* The contractor shall do all rock excavation to the depth shown on plans plus at least four (4) inches. Rock excavation shall consist of the removal of boulders and detached rock, one-half ($\frac{1}{2}$) cubic yard in volume or greater, and of all rock in place in ledges or masses which can be removed only by the use of bars and sledges or by blasting.

When rock or non-cushioning material is encountered in trench excavation, a cushion at least four (4) inches thick shall be placed between the rock and the bottom of the pipe. The cushion shall consist of clean sand or equivalent granular material. The cost of furnishing and placing the cushion material shall be included in the bid price per cubic yard for rock excavation. Before any rock is removed, the engineer shall have the opportunity to obtain the necessary data to determine the yardage to be used for payment. The bottom of the trench shall be excavated to a horizontal section as far as practicable.

(c) *General.* Excavated material not required or acceptable for backfill shall be disposed of by the contractor as directed by the engineer. Common excavation shall not be carried below the required depth; when this is done the trench shall be backfilled at the contractor's expense, with material approved by the engineer and compacted to the density of the surrounding earth material, as determined by the CAA compaction control tests T-611.

When directed, unstable soil shall be removed for the full width of the trench and replaced with sand or with approved granular material. The engineer shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe. When not specified in the special provisions, the cost of removing unstable soil

and replacing it with approved material shall be covered by a supplemental agreement for the cubic yards of excavation and the cubic yards of approved material.

The depth of cut shown on the plans is from the surface grade to the invert of the pipe line. In case the depth of cut is changed from that shown on the plans, the change shall not exceed six (6) inches without a revision in the contract unit price per linear foot of pipe. However, if the depth of cut is changed more than six (6) inches, compensation or deduction of work involved, whether increased or decreased shall be provided for in a supplemental agreement.

The minimum width of the trench at the top of the pipe when placed shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the outside diameter of the pipe plus six (6) inches on each side of the pipe. The trench shall be excavated accurately to the established line so that at least a six (6) inch space will exist between the side of the trench and the side of the pipe. The sides of the trenches shall be vertical, unless otherwise approved by the engineer. The maximum allowable width of trench shall not exceed twelve (12) inches on each side of the pipe when placed, unless otherwise approved by the engineer.

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Spaces for the pipe bell shall be excavated accurately to size to clear the bell so that the barrel supports the entire weight of the pipe.

The contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation; also, as required for safety and to conform to governing laws. Unless otherwise provided, the bracing, sheathing, or shoring shall be removed by the contractor after the completion of the backfill to at least six (6) inches over the top of the pipe. The cost of the bracing, sheathing or shoring, and the removal of same, shall be included in the unit price bid per foot for the pipe.

702-3.3 CRADLES. When the engineer finds the bottom of the trench to be an insufficient foundation for the pipe, he shall determine the locations and dimensions of the necessary cradles to properly support the pipe. The design details for the cradles shall be as shown on the plans.

702-3.4 LAYING AND INSTALLING PIPE. The contractor shall provide the necessary mason's lines and supports to insure installation of the pipe to line and grade, as staked by the engineer. The contractor's facilities for lowering the pipe into the trench shall be such that neither the pipe nor the trench will be damaged or disturbed.

The engineer shall inspect all pipe before it is laid, and reject any section that is damaged by handling or is found to be defective to a degree which will materially affect the function and service of the pipe.

The laying of the pipe in the finished trench shall be started at the lowest point and laid upgrade. When bell and spigot pipe is used the

bell shall be laid upgrade. If tongue and groove pipe is used, the groove end shall be laid upgrade.

The pipe shall be firmly and accurately set to line and grade so that the invert will be smooth and uniform. The pipe shall be protected from water during placing and until the mortar in the joints has thoroughly set.

Pipe shall not be laid on frozen ground.

When placing concrete pipe constructed with elliptical reinforcing, the pipe shall be oriented in accordance with the manufacturer's markings of top or bottom.

The upgrade end of pipe lines not terminating in a structure shall be plugged with a cap or plug approved by the engineer.

Pipe which is not true in alignment, or which shows any settlement after laying, shall be taken up and relaid without extra compensation.

702-3.5 MORTAR. Mortar shall be mixed in a ratio of one part by volume of Portland cement and two parts by volume of sand. The mortar shall be of the desired consistency for caulking and filling the joints of the pipe. Mortar that is not used within forty-five (45) minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

702-3.6 PIPE JOINTS. Closed joints for storm sewers and for culvert pipe shall be made as follows:

All pipe shall be carefully laid, bell or groove end upgrade, spigot or tongue end fully entered into the adjacent hub, and true to lines and grades given.

The joints of the concrete pipe shall be caulked and filled with the specified mortar. Joints of concrete pipe shall be thoroughly wet before making the joint.

Before succeeding sections of pipe are laid, the lower portions of the bell or groove of the pipe shall be filled on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. After the pipe is laid, the remainder of the joints shall be solidly filled with mortar and sufficient additional mortar used to form a bead or ring around the outside of the joint. The inside of the joint shall be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap.

702-3.7 BACKFILLING. All trenches and excavations shall be backfilled in a reasonable time after the pipes are installed therein unless other protection of the pipe is directed by the engineer. The backfill material shall be approved by the engineer. Backfill material containing stones or rock exceeding three (3) inches in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds one (1) foot. Backfill material containing rock three (3) inches in diameter or larger shall not be used in trenches under paved areas. Special care shall be taken in placing the backfill. Great care shall be used to obtain thorough compaction under the haunches and along the sides to the top of the pipe.

The backfill shall be placed in loose layers not exceeding six (6) inches in depth under and around the pipe, and not exceeding eight (8) inches over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the engineer, until the trench is completely filled and brought to the elevation as directed. Backfilling shall be done in such a manner as to avoid injurious top or side pressures on the pipe.

In embankments and for other areas outside of pavements, the backfill shall be compacted to the density as required for embankments in Item P-152, and determined by CAA compaction control tests T-611, for the class of airport involved. Under paved areas, the subgrade and any backfill up to a depth of five (5) feet below the subgrade shall be compacted to the same requirements as given for subgrades in Item P-152; below a depth of five (5) feet from the subgrade, the compaction shall be as stated for embankments.

702-3.8 CONNECTIONS. Where the plans call for connections to existing or proposed structures, these connections shall be watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

702-3.9 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the pipe.

702-3.10 INSPECTION. Prior to final approval of the drainage system the engineer, accompanied by the contractor's representative, shall make a thorough inspection, by an appropriate method, of the entire installation. Any indication of defects in material or workmanship or obstruction to flow in the pipe system shall be further investigated and corrected as necessary. Defects due to the contractor's negligence shall be corrected by the contractor without additional compensation, and as directed by the engineer.

METHOD OF MEASUREMENT

702-4.1 The footage of pipe to be paid for shall be the number of linear feet of pipe in place, completed and approved; measured along the centerline of the pipe from end or inside face of structure, to end or inside face of structure, whichever is applicable. The several classes, types, and sizes shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe line being measured.

702-4.2 The volume of concrete for pipe cradles to be paid for shall be the number of cubic yards of concrete complete in place and accepted, determined from the dimensions shown on the plans, or as ordered by the engineer.

702-4.3 Rock required to be removed shall be computed by the cubic yard for the specified width of the trench and to a depth of four (4) inches below the bed of the pipe. No payment will be made for the cushion material placed for the bed of the pipe.

BASIS OF PAYMENT

702-5.1 The footage of pipe, measured as provided in Section 4.1, shall be paid for at the contract unit price per linear foot for "Concrete Pipe" of the several classes, types, and sizes, which price and payment shall constitute full compensation for furnishing, hauling, and installing the pipe; for common excavation; for backfill and compaction; for jointing; for connections to drainage structures; and for all material, labor, equipment, tools, and incidentals necessary to complete the drain as shown on the plans, but shall not constitute payment for manholes, catch basins, inlets, cradles, inspection holes, or headwalls, the payment for which is provided for as separate items.

702-5.2 The cubic yards of concrete determined as provided in Section 4.2 shall be paid for at the contract unit price per cubic yard for "Concrete for Pipe Cradles," which price and payment shall constitute full compensation for concrete in place including reinforcing when shown on the plans.

702-5.3 The cubic yards of rock excavation, determined as provided in Section 4.3, shall be paid for at the contract unit price per cubic yard for "Rock Excavation," which price and payment shall constitute full compensation for excavation, placing cushion material, and disposal of material as defined.

Payment will be made under:

- Item D-702-5.1 ----inch Standard Nonreinforced Concrete Sewer Pipe—per linear foot.
- Item D-702-5.1 ----inch Standard Reinforced Concrete Sewer Pipe—per linear foot.
- Item D-702-5.1 ----inch Standard Strength Reinforced Concrete Culvert Pipe—per linear foot.
- Item D-702-5.1 ----inch Extra Strength Reinforced Concrete Culvert Pipe—per linear foot.
- Item D-702-5.2 Concrete for Pipe Cradles—per cubic yard.
- Item D-702-5.3 Rock Excavation—per cubic yard.

ITEM D-703 CORRUGATED METAL PIPE, GALVANIZED, OR GALVANIZED AND BITUMINOUS-COATED, FOR STORM SEWERS AND CULVERTS

DESCRIPTION

703-1.1 This item shall consist of corrugated sheet metal pipe of the types, classes, sizes, gauges, and dimensions required on the plans, furnished and installed at such places as are designated on the plans and profiles, or by the engineer, in accordance with these specifications and in conformity with the lines and grades given.

The item shall include, in the bid price per linear foot of pipe in place, the cost of common excavation and backfill, the cost of furnishing and installing all trench bracing, all fittings required to complete the pipe drain, as shown on the plans; and the material for and the making of all joints, including all connections to existing drainage pipes and structures.

MATERIALS

703-2.1 GENERAL. The pipe shall be of the type called for on the plans or in the proposal and shall be in accordance with the following appropriate requirements. When the plans or the proposals permit a choice of pipe, the contractor shall indicate in the bid the type proposed to be furnished.

703-2.2 CORRUGATED METAL CULVERT PIPE. Corrugated metal culvert pipe shall conform to the requirements of A. A. S. H. O. Specification M-36.

703-2.3 BITUMINOUS-COATED CORRUGATED METAL CULVERT PIPE. The pipe shall conform to all the requirements of A. A. S. H. O. Specification M-36, and in addition shall be coated with an asphalt cement that will meet the following requirements:

(a) *Type 1—Coated Pipe.* The pipe shall be coated uniformly, inside and out, to a minimum thickness of 0.05 of an inch, measured on the crests of the corrugations.

(b) *Type 2—Coated and Paved Pipe.* The pipe shall be coated as required for Type 1 pipe. In addition, bituminous material shall be applied in such a manner that a smooth pavement will be formed in the invert (bottom of pipe when installed) and the corrugations will be filled for one-quarter of the circumference of the pipe. The pavement, except where the upper edges intersect the corrugations, shall have a minimum thickness of 0.37 inch, measured on the crests of the corrugations.

(c) *Bituminous Material.* The tests on the bituminous coating shall be made on samples secured from pipe delivered to, or about to be delivered to, the project. The asphalt cement shall be not less than 99.5 percent soluble in carbon disulphide (A. A. S. H. O. Method T-44). The loss on heating the material to 325° F. shall not exceed one (1) percent (A. A. S. H. O. Method T-47). The penetration of the residue from loss on heating, compared with the penetration of same sample before heating, shall be not less than eighty-five (85) percent (A. A. S. H. O. Method T-49). The asphalt cement shall adhere to the metal tenaciously, shall not chip off in handling, and shall protect the pipe from deterioration, as evidence by meeting the following tests successfully:

(1) **STABILITY TEST.** The asphalt cement shall not lose its stability when subjected to the highest summer temperature, as indicated by passing the test performed as follows: Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant temperature oven, with the parallel lines in a horizontal position. The temperature of the specimen shall be maintained within 2° F. of 150° F., for a period of 4 hours. At the end of this time no part of any line shall have dropped more than one-fourth ($\frac{1}{4}$) inch.

(2) **IMPERVIOUSNESS TEST.** The asphalt cement shall be impervious to liquids as indicated by passing the test performed as follows: A 25-percent solution of sulphuric acid, or a 25-percent solution of sodium hydroxide, or a saturated salt solution (such as sodium chloride) shall be held in the valley of a corrugation for a period of 48 hours, during which time no loosening or separation of the bituminous material from the galvanizing shall have taken place.

703-2.4 MORTAR. Mortar for connections to drainage structures shall be composed of one part by volume of Portland cement and two parts of mortar sand. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. Hydrated lime may be added to the mixture of sand and cement in an amount equal to fifteen (15) percent of the weight of cement used.

CONSTRUCTION METHODS

703-3.1 EQUIPMENT. All equipment necessary and required for the proper construction of storm sewers and culverts shall be on the project, in first class working condition, and shall have been approved by the engineer before construction is permitted to start.

The contractor shall provide such hand tampers and pneumatic tampers to obtain the compaction of the pipe bed and the backfill as specified.

703-3.2 EXCAVATION. (a) *Common.* The contractor shall do all common excavation to the depth shown on the plans. Common excavation shall consist of all excavation not included under rock excavation.

(b) *Rock.* The contractor shall do all rock excavation to the depth shown on plans plus at least four (4) inches. Rock excavation shall consist of the removal of boulders and detached rock, one-half ($\frac{1}{2}$) cubic yard in volume or greater, and of all rock in place in ledges or masses which can be removed only by the use of bars and sledges or by blasting.

When rock or noncushioning material is encountered in trench excavation, a cushion at least four (4) inches thick shall be placed between the rock and the bottom of the pipe. The cushion shall consist of clean sand or equivalent granular material. The cost of furnishing and placing the cushion material shall be included in the bid price per cubic yard for rock excavation. Before any rock is removed, the engineer shall have the opportunity to obtain the necessary data to determine the yardage to be used for payment. The bottom of the trench shall be excavated to a horizontal section as far as practicable.

(c) *General.* Excavated material not required or acceptable for backfill shall be disposed of by the contractor as directed by the engineer. Common excavation shall not be carried below the required depth; when this is done the trench shall be backfilled at the contractor's expense with material approved by the engineer and compacted to the density of the surrounding earth material as determined by the CAA compaction control tests T-611.

When directed, unstable soil shall be removed for the full width of the trench and replaced with sand or with approved granular material. The engineer shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe. When not specified in the special provisions, the cost of removing unstable soil and replacing it with approved material shall be covered by a supplemental agreement for the cubic yards of excavation and the cubic yards of approved material.

The depth of cut shown on the plans is from the surface grade to the invert of the pipe line. In case the depth of cut is changed from that shown on the plans, the change shall not exceed six (6) inches without a revision in the contract unit price per linear foot of pipe. However, if the depth of cut is changed more than six (6) inches, compensation or deduction of work involved, whether increased or decreased, shall be provided for in a supplemental agreement.

The minimum width of the trench at the top of the pipe, when placed, shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the outside diameter of the pipe plus six (6) inches on each side of the pipe. The trench shall be excavated accurately to the established line so that at least a six (6) inch space will exist between the side of the trench and the side of the pipe. The sides of the trenches shall be vertical, unless otherwise approved by the engineer. The maximum allowable width of trench shall not exceed twelve (12) inches on each side of the pipe when placed, unless otherwise approved by the engineer.

372 703. METAL PIPE FOR SEWERS AND CULVERTS

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench.

The contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation; also, as required for safety and to conform to governing laws. Unless otherwise provided the bracing, sheathing, or shoring shall be removed by the contractor after the completion of the backfill to at least six (6) inches over the top of the pipe. The cost of the bracing, sheathing, or shoring, and the removal of same, shall be included in the unit price bid per foot for the pipe.

703-3.3 PLACING PIPE. The pipe shall be laid with the separate sections joined firmly together, with coupling bands described in A. A. S. H. O. Specification M-36, with outside laps of circumferential joints pointing upgrade, and with longitudinal laps on the sides. Any metal in the pipe or bands which is not protected thoroughly by galvanizing shall be coated with a suitable asphaltum paint.

Proper facilities shall be provided for lowering the pipe when it is to be placed in a trench. The pipe shall be laid carefully and true to lines and grades on a bed which is uniformly firm throughout its entire length. Any pipe which is not in true alignment, or which shows any undue settlement after being laid or is damaged, shall be taken up and relaid or replaced without extra compensation.

During installation, the asphalt-protected pipe shall be handled without damaging the asphalt coating. The pipe shall be placed so that the element of the cylindrical pipe constituting the centerline of the paved section shall coincide with the flow line of the culvert or sewer. Sections of paved pipe shall be laid so that the flow line is smooth and continuous across joints.

Any breaks in the bitumen or treatment of Type 1 or Type 2 pipe shall be repaired with the type and kind of bitumen used in coating the pipe originally.

Pipes 48 inches or larger in diameter shall be strutted as shown on the plans. The struts shall be placed before the backfill or embankment is made, and shall be removed when removal is ordered by the engineer.

Pipe shall not be laid on frozen ground.

703-3.4 MORTAR. Mortar shall be mixed in a ratio of one part by volume of Portland cement and two parts by volume of sand. The mortar shall be of the desired consistency for caulking and filling between the pipe and the drainage structures. Mortar that is not used within forty-five (45) minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

703-3.5 BACKFILLING. All trenches and excavations shall be backfilled in a reasonable time after the pipes are installed therein unless other protection of the pipe is directed by the engineer. The

backfill material shall be approved by the engineer. Backfill material containing stones or rock exceeding three (3) inches in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds one (1) foot. Backfill material containing rock three (3) inches in diameter or larger shall not be used in trenches under paved areas. Special care shall be taken in placing the backfill. Great care shall be used to obtain thorough compaction under the haunches and along the sides to the top of the pipe.

The backfill shall be placed in loose layers not exceeding six (6) inches in depth under and around the pipe, and not exceeding eight (8) inches over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the engineer, until the trench is completely filled and brought to the elevation as directed. Backfilling shall be done in such a manner as to avoid injurious top or side pressures on the pipe.

In embankments and for other areas outside of pavements, the backfill shall be compacted to the density as required for embankments in Item P-152 and determined by CAA compaction control tests T-611 for the class of airport involved. Under paved areas, the subgrade and any backfill up to a depth of five (5) feet below the subgrade shall be compacted to the same requirements as given for subgrades in Item P-152; below a depth of five (5) feet from the subgrade, the compaction shall be as stated for embankments.

703-3.6 CONNECTIONS. Where the plans call for connections to existing or proposed structures, these connections shall be watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

703-3.7 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the pipe.

703-3.8 INSPECTION. Prior to final approval of the drainage system the engineer, accompanied by the contractor's representative, shall make a thorough inspection, by an appropriate method, of the entire installation. Any indication of defects in material or workmanship, or obstruction to flow in the pipe system, shall be further investigated and corrected as necessary. Defects due to the contractor's negligence shall be corrected by the contractor without additional compensation, and as directed by the engineer.

374 703. METAL PIPE FOR SEWERS AND CULVERTS

METHOD OF MEASUREMENT

703-4.1 The footage of pipe to be paid for shall be the number of linear feet of pipe in place, completed and approved; measured along the centerline of the pipe from end or inside face of structure to end, or inside face of structure, whichever is applicable. The several classes, types, and sizes shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe line being measured.

703-4.2 Rock required to be removed shall be computed by the cubic yard for the specified width of the trench and to a depth of four (4) inches below the bed of the pipe. No payment will be made for the cushion material placed for the bed of the pipe.

BASIS OF PAYMENT

703-5.1 The footage of pipe, measured as provided in Section 4.1, shall be paid for at the contract unit price per linear foot for "Corrugated Metal Culvert Pipe" of the several types, classes, gauges, and sizes, which price and payment shall constitute full compensation for furnishing, hauling, and installing the pipe; for common excavation; for backfill and compaction; for jointing; for connections to drainage structures; and for all material, labor, equipment, tools, and incidentals necessary to complete the drain as shown on the plans, but shall not constitute payment for manholes, catch basins, inlets, inspection holes, or headwalls, the payment for which is provided for as separate items.

703-5.2 The cubic yards of rock excavation, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Rock Excavation," which price and payment shall constitute full compensation for excavation, placing cushion material, and disposal of material as defined.

Payment will be made under:

- Item D-703-5.1 ----inch Corrugated Metal Culvert Pipe—per linear foot.
- Item D-703-5.1 ----inch Bituminous-Coated Corrugated Metal Culvert Pipe—per linear foot.
- Item D-703-5.1 ----inch Bituminous-Coated Paved Invert Corrugated Metal Culvert Pipe—per linear foot.
- Item D-703-5.2 Rock Excavation—per cubic yard.

ITEM D-704 CAST IRON PIPE FOR STORM SEWERS AND CULVERTS

DESCRIPTION

704-1.1 This item shall consist of cast-iron pipe of the types, classes, sizes, and dimensions required on the plans, furnished and installed at such places as are designated on the plans and profiles, or by the engineer, in accordance with these specifications and in conformity with the lines and grades given.

The item shall include in the bid price per linear foot of pipe in place, the cost of common excavation and backfill, the cost of furnishing and installing all trench bracing, all fittings required to complete the pipe drain, as shown on the plans; and the material for and the making of all joints, including all connections to existing drainage pipes and structures.

MATERIALS

704-2.1 GENERAL. Pipe shall be of the type or types and the class or classes called for in the bid schedule. The types are identified as "Smooth," "Corrugated," or "Ribbed." The classes are identified as "Standard (2000D)," "Heavy" (3000D), or "Extra Heavy" (4000D). When the bid schedule or plans do not indicate the type, the contractor may furnish the type of his choice, except that for each class required only one type shall be furnished on a single job.

704-2.2 CAST IRON CULVERT PIPE. The pipe shall conform to all the requirements of A. A. S. H. O. Specification M-64.

704-2.3 MORTAR. Mortar for pipe joints and connections to drainage structures shall be composed of one part by volume of Portland cement and one and one-half parts of mortar sand. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. Hydrated lime may be added to the mixture of sand and cement in an amount equal to fifteen (15) percent of the weight of cement used.

704-2.4 CONCRETE. Concrete for pipe cradles shall conform to the requirements of Item P-610.

CONSTRUCTION METHODS

704-3.1 EQUIPMENT. All equipment necessary and required for the proper construction of storm sewers and culverts shall be on the project, in first class working condition, and shall have been approved by the engineer before construction is permitted to start.

The contractor shall provide hoisting equipment to handle the pipe in unloading and placing in its final position, without damage to the pipe.

The contractor shall provide such hand tampers and pneumatic tampers to obtain the compaction of the pipe bed and the backfill as specified.

704-3.2 EXCAVATION. (a) *Common.* The contractor shall do all common excavation to the depth shown on the plans. Common excavation shall consist of all excavation not included under rock excavation.

(b) *Rock.* The contractor shall do all rock excavation to the depth shown on plans plus at least four (4) inches. Rock excavation shall consist of the removal of boulders and detached rock, one-half ($\frac{1}{2}$) cubic yard in volume or greater, and of all rock in place in ledges or masses which can be removed only by the use of bars and sledges or by blasting.

When rock or noncushioning material is encountered in trench excavation, a cushion at least four (4) inches thick shall be placed between the rock and the bottom of the pipe. The cushion shall consist of clean sand or equivalent granular material. The cost of furnishing and placing the cushion material shall be included in the bid price per cubic yard for rock excavation. Before any rock is removed, the engineer shall have the opportunity to obtain the necessary data to determine the yardage to be used for payment. The bottom of the trench shall be excavated to a horizontal section as far as practicable.

(c) *General.* Excavated material not required or acceptable for backfill shall be disposed of by the contractor as directed by the engineer. Common excavation shall not be carried below the required depth; when this is done the trench shall be backfilled at the contractor's expense with material approved by the engineer and compacted to the density of the surrounding earth material, as determined by the CAA compaction control tests T-611.

When directed, unstable soil shall be removed for the full width of the trench and replaced with sand or with approved granular material. The engineer shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe. When not specified in the special provisions, the cost of removing unstable soil and replacing it with approved material shall be covered by a supplemental agreement for the cubic yards of excavation and the cubic yards of approved material.

The depth of cut shown on the plans is from the surface grade to the invert of the pipeline. In case the depth of cut is changed from that shown on the plans, the change shall not exceed six (6) inches without a revision in the contract unit price per linear foot of pipe. However, if the depth of cut is changed more than six (6) inches, compensation or deduction of work involved, whether increased or decreased, shall be provided for in a supplemental agreement.

The minimum width of the trench at the top of the pipe when placed shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the outside diameter of the pipe plus six (6) inches on each side of the pipe. The trench shall be excavated accurately to the established line so that at least a six (6) inch space will exist between the side of the trench and the side of the pipe. The sides of the trenches shall be vertical, unless otherwise approved by the engineer. The maximum allowable width of trench shall not exceed twelve (12) inches on each side of the pipe when placed, unless otherwise approved by the engineer.

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Spaces for the pipe bell shall be excavated accurately to size to clear the bell so that the barrel supports the entire weight of the pipe.

The contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation; also, as required for safety and to conform to governing laws. Unless otherwise provided, the bracing, sheathing, or shoring shall be removed by the contractor after the completion of the backfill to at least six (6) inches over the top of the pipe. The cost of the bracing, sheathing, or shoring, and the removal of same, shall be included in the unit price bid per foot for the pipe.

704-3.3 CRADLES. When the engineer finds the bottom of the trench to be on insufficient foundation for the pipe, he shall determine the locations and dimensions of the necessary cradles to properly support the pipe. The design details for the cradles shall be as shown on the plans.

704-3.4 LAYING AND INSTALLING PIPE. The contractor shall provide the necessary mason's lines and supports to insure installation of the pipe to line and grade as staked by the engineer. The contractor's facilities for lowering the pipe into the trench shall be such that neither the pipe nor the trench will be damaged or disturbed.

The engineer shall inspect all pipe before it is laid and reject any section that is damaged by handling or is found to be defective to a degree which will materially affect the function and service of the pipe.

The laying of the pipe in the finished trench shall be started at the lowest point and laid upgrade. When bell and spigot pipe is used the bell shall be laid upgrade.

The pipe shall be firmly and accurately set to line and grade so that the invert will be smooth and uniform. The pipe shall be protected from water during placing and until the mortar in the joints has thoroughly set.

Pipe shall not be laid on frozen ground.

The upgrade end of pipe lines not terminating in a structure shall be plugged with a cap or plug approved by the engineer.

Pipe which is not true in alignment, or which shows any settlement after laying, shall be taken up and relaid without extra compensation.

704-3.5 MORTAR. Mortar shall be mixed in a ratio of one part by volume of Portland cement and one and one-half parts by volume of sand. The mortar shall be of the desired consistency for caulking and filling the joints of the pipe. Mortar that is not used within forty-five (45) minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

704-3.6 PIPE JOINTS. All pipe shall be carefully laid, bell end upgrade, spigot end fully entered into the adjacent bell, and true to lines and grade.

All joints of cast iron pipe, unless otherwise specified, shall be caulked and filled with the specified mortar.

Before succeeding sections of pipe are laid, the lower portions of the bell of the pipe shall be filled on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. After the pipe is laid, the remainder of the joints shall be solidly filled with mortar and sufficient additional mortar used to form a bead or ring around the outside of the joint. The inside of the joint shall be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap.

704-3.7 BACKFILLING. All trenches and excavations shall be backfilled in a reasonable time after the pipes are installed therein, unless other protection of the pipe is directed by the engineer. The backfill material shall be approved by the engineer. Backfill material containing stones or rock exceeding three (3) inches in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds one (1) foot. Backfill material containing rock three (3) inches in diameter or larger shall not be used in trenches under paved areas. Special care shall be taken in placing the backfill. Great care shall be used to obtain thorough compaction under the haunches and along the sides to the top of the pipe.

The backfill shall be placed in loose layers not exceeding six (6) inches in depth under and around the pipe, and not exceeding eight (8) inches over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the engineer, until the trench is completely filled and brought to the elevation, as directed. Backfilling shall be done in such a manner as to avoid injurious top or side pressures on the pipe.

In embankments and for other areas outside of pavements the backfill shall be compacted to the density as required for embankments in Item P-152 and determined by CAA compaction control tests T-611 for the class of airport involved. Under paved areas the subgrade and any backfill up to a depth of five (5) feet below the subgrade shall be compacted to the same requirements as given for subgrades in Item P-152; below a depth of five (5) feet from the subgrade, the compaction shall be as stated for embankments.

704-3.8 CONNECTIONS. Where the plans call for connections to existing or proposed structures, these connections shall be

watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

704-3.9 CLEANING AND RESTORATION OF SITE.

After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the pipe.

704-3.10 INSPECTION. Prior to final approval of the drainage system the engineer, accompanied by the contractor's representative, shall make a thorough inspection, by an appropriate method, of the entire installation. Any indication of defects in material or workmanship, or obstruction to flow in the pipe system, shall be further investigated and corrected as necessary. Defects due to the contractor's negligence shall be corrected by the contractor without additional compensation, and as directed by the engineer.

METHOD OF MEASUREMENT

704-4.1 The footage of pipe to be paid for shall be the number of linear feet of pipe in place, completed and approved; measured along the centerline of the pipe from end or inside face of structure, to end or inside face of structure, whichever is applicable. The several classes, types, and sizes shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe line being measured.

704-4.2 The volume of concrete for pipe cradles to be paid for shall be the number of cubic yards of concrete complete in place and accepted, determined from the dimensions shown on the plans, or as ordered by the engineer.

704-4.3 Rock, required to be removed, shall be computed by the cubic yard for the specified width of the trench and to a depth of four (4) inches below the bed of the pipe. No payment will be made for the cushion material placed for the bed of the pipe.

BASIS OF PAYMENT

704-5.1 The footage of pipe, measured as provided in Section 4.1, shall be paid for at the contract unit price per linear foot for "Cast Iron Pipe" of the several classes, types, and sizes, which price and payment shall constitute full compensation for furnishing, hauling, and installing the pipe; for common excavation; for backfill and compaction; for jointing; for connections to drainage structures; and

for all material, labor, equipment, tools, and incidentals necessary to complete the drain as shown on the plans, but shall not constitute payment for manholes, catch basins, inlets, cradles, inspection holes or headwalls, the payment for which is provided for as separate items.

704-5.2 The cubic yards of concrete, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Concrete for Pipe Cradles," which price and payment shall constitute full compensation for concrete in place, including reinforcing when shown on the plans.

704-5.3 The cubic yards of rock excavation, determined as provided in Section 4.3, shall be paid for at the contract unit price per cubic yard for "Rock Excavation," which price and payment shall constitute full compensation for excavation, placing cushion material, and disposal of material as defined.

Payment will be made under:

- Item D-704-5.1 ----inch Standard Cast Iron Culvert Pipe—per linear foot.
- Item D-704-5.1 ----inch Heavy Cast Iron Culvert Pipe—per linear foot.
- Item D-704-5.1 ----inch Extra Heavy Cast Iron Culvert Pipe—per linear foot.
- Item D-704-5.2 Concrete for Pipe Cradles—per cubic yard.
- Item D-704-5.3 Rock Excavation—per cubic yard.

ITEM D-705 PIPE UNDERDRAINS FOR AIRPORTS

DESCRIPTION

705-1.1 This item shall consist of pipe underdrains of the types, classes, sizes, and dimensions required on the plans, furnished and installed at such places as are designated on the plans and profiles, or by the engineer, in accordance with these specifications and in conformity with the line and grades given.

The item shall include in the bid price per linear foot of pipe in place, the cost of excavation, the cost of furnishing and installing all trench bracing, all fittings required to complete the underdrain, as shown on the plans; and the material for and the making of all joints, including all connections to existing drainage pipes and structures.

The bid price per linear foot of pipe shall include all backfill made with earth excavated from the immediate trench. When a granular backfill, as called for on the plans or as ordered by the engineer, is used to replace material excavated from the trench, it shall be bid and paid for separately as Porous Backfill No. 1 and/or No. 2, per cubic yard in place and compacted.

MATERIALS

705-2.1 GENERAL. The pipe shall be of the type called for on the plans or in the proposal, and shall be in accordance with the following appropriate requirements. When the plans or the proposals permit a choice of pipe, the contractor shall indicate in the bid the type proposed to be furnished.

705-2.2 VITRIFIED CLAY PIPE. Standard-strength vitrified clay pipe shall conform to the requirements of A. A. S. H. O. Specification M-65.

705-2.3 VITRIFIED CLAY CRADLE INVERT PIPE. The vitrified clay cradle invert pipe shall meet the requirements of A. A. S. H. O. Specification M-65. The socket or bell end shall have four lugs properly located, two near the bottom or flow line to produce a positive standard annular space, and a fixed transverse slot one-eighth ($\frac{1}{8}$) of an inch between two adjacent sections of pipe.

705-2.4 PERFORATED VITRIFIED CLAY PIPE. In addition to conforming to the specifications of Section 2.2, the clay pipe, when required, shall be perforated as follows:

Perforations shall be circular and one quarter ($\frac{1}{4}$) inch (plus or minus $\frac{1}{16}$ inch) in diameter, arranged in rows parallel to the axis of

the pipe. Perforations shall be spaced approximately three (3) inches center to center along the rows. The holes shall be cleanly formed and present full openings. The spigot end shall be unperforated for a length equal to the depth of socket.

The rows of holes shall be arranged in two equal groups, one on each side of the vertical centerline of the pipe, and the total number of rows shall be four in 4-, 6-, and 8-inch pipe; and six in 10-, 12-, and 15-inch pipe.

The longitudinal rows of perforations shall be symmetrical about a diametrical axis and located in one semicircumference. The limiting rows will be separated by an arc of 90 degrees and an arc at least 160 degrees and less than 180 degrees. Additional longitudinal rows will be uniformly spaced within these limiting rows.

705-2.5 CONCRETE SEWER PIPE, STANDARD, NON-REINFORCED. Concrete sewer pipe, standard, nonreinforced, shall conform to the requirements of A. A. S. H. O. Specification M-86.

705-2.6 PERFORATED CONCRETE PIPE. In addition to conforming to the specifications of Section 2.5, the concrete pipe, when required, shall be perforated as follows:

Perforations shall be circular and one quarter ($\frac{1}{4}$) inch (plus or minus $\frac{1}{16}$ inch) in diameter, arranged in rows parallel to the axis of the pipe. Perforations shall be spaced approximately three (3) inches center to center along the rows. The holes shall be cleanly formed and present full openings. The spigot end shall be unperforated for a length equal to the depth of socket.

The rows of holes shall be arranged in two equal groups, one on each side of the vertical centerline of the pipe, and the total number of rows shall be four in 4-, 6-, and 8-inch pipe; and six in 10-, 12-, and 15-inch pipe.

The longitudinal rows of perforations shall be symmetrical about a diametrical axis and located in one semicircumference. The limiting rows will be separated by an arc of 90 degrees and an arc at least 160 degrees and less than 180 degrees. Additional longitudinal rows will be uniformly spaced within these limiting rows.

705-2.7 CORRUGATED METAL PIPE. Corrugated metal pipe shall conform to the requirements of A. A. S. H. O. Specification M-136. If the pipe is required to be coated, it shall meet the requirements of Item D-703, Section 2.3. When perforated corrugated metal pipe is required to be coated, the perforations shall not be stopped up, but shall present full openings.

The perforation for the pipe shall be located in the inside crests of the corrugations, and shall have a diameter of not less than one-quarter ($\frac{1}{4}$) inch, nor more than three-eighths ($\frac{3}{8}$) inch.

705-2.8 POROUS BACKFILL. Porous backfill shall be free of clay, humus, or other objectionable matter, and shall also conform to particle size specified.

Sieve size	Percent by weight passing square mesh sieves	
	Porous material No. 1	Porous material No. 2
1½ inches		100
1 inch		90-100
¾ inch	100	25- 60
No. 4	95-100	5- 40
No. 8		0- 20
No. 16	45- 80	
No. 50	10- 30	
No. 100	0- 10	

Two courses of porous backfill are required. The finer of the materials shall conform to particle size tabulated herein for porous material No. 1. The coarser granular material shall meet the gradation given in the tabulation for porous material No. 2.

705-2.9 MORTAR. Mortar for pipe connections to other drainage structures shall be composed of one part by volume of Portland cement and two parts of mortar sand. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. Hydrated lime may be added to the mixture of sand and cement in an amount equal to fifteen (15) percent of the weight of cement used.

CONSTRUCTION METHODS

705-3.1 EQUIPMENT. All equipment necessary and required for the proper construction of pipe underdrains shall be on the project, in first class working condition, and shall have been approved by the engineer before construction is permitted to start.

The contractor shall provide such hand tampers and pneumatic tampers to obtain the compaction of the pipe bed and the backfill as specified.

705-3.2 EXCAVATION. The contractor shall do all necessary excavation to the depth shown on the plans. The excavation shall be unclassified and shall be performed regardless of the material encountered.

When rock or noncushioning material is encountered in trench excavation, a cushion at least four (4) inches thick shall be placed between the rock and the bottom of the pipe. The cushion shall consist of clean sand or equivalent granular material. The cost of furnishing and placing the cushion material shall be included in the bid price per linear foot of pipe. When rock is encountered, the bottom of the trench shall be excavated to a horizontal section as far as is practicable.

Excavated material not required or acceptable for backfill shall be disposed of by the contractor as directed by the engineer. The excavation shall not be carried below the required depth; when this is done the trench shall be backfilled at the contractor's expense, with material approved by the engineer, and compacted to the density of the surrounding earth material, as determined by the CAA compaction control tests T-611.

The depth of cut shown on the plans is from the surface grade to the invert of the pipe line. In case the depth of cut is changed from that shown on the plans, the change shall not exceed six (6) inches without a revision in the contract unit price per linear foot of pipe. However, if the depth of cut is changed more than six (6) inches, compensation or deduction of work involved, whether increased or decreased, shall be provided for in a supplemental agreement.

The minimum width of the trench at the top of the pipe, when placed, shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the outside diameter of the pipe plus six (6) inches on each side of the pipe.

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Spaces for the pipe bell shall be excavated accurately to size to clear the bell so that the barrel supports the entire weight of the pipe.

The contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation; also, as required for safety, and to conform to governing laws. Unless otherwise provided the bracing, sheathing, or shoring shall be removed by the contractor after the completion of the backfill to at least six (6) inches over the top of the pipe. The cost of bracing, sheathing, or shoring, and the removal of same, shall be included in the unit price bid per foot for the pipe.

705-3.3 LAYING AND INSTALLING PIPE. (a) *Nonmetallic Pipe.* The contractor shall provide the necessary mason's lines and supports to insure installation of the pipe to line and grade, as staked by the engineer. The contractor's facilities for lowering the pipe into the trench shall be such that neither the pipe nor the trench will be damaged or disturbed.

The engineer shall inspect all pipe before it is laid and reject any section that is damaged by handling or is found to be defective to a degree which will materially affect the function and service of the pipe.

The laying of the pipe in the finished trench shall be started at the lowest point and laid upgrade. When bell and spigot pipe is used, the bells shall be laid upgrade. If tongue and groove pipe is used, the groove end shall be laid upgrade. Holes in perforated pipe shall be placed as shown on the plans. The pipe shall be firmly and accurately set to line and grade so that the invert will be smooth and uniform. Pipe shall not be laid on frozen ground.

The upgrade end of pipe lines, not terminating in a structure, shall be plugged with a cap or plug approved by the engineer.

Pipe which is not true in alignment, or which shows any settlement after laying, shall be taken up and relaid without extra compensation.

(b) *Corrugated Metal Pipe.* The pipe shall be laid with the separate sections joined firmly together with bands; with outside laps of circumferential joints pointing upgrade, and with longitudinal laps on the sides. Any metal in the pipe or bands which is not protected thoroughly by galvanizing shall be coated with a suitable asphaltum paint.

Proper facilities shall be provided for lowering the pipe when it is to be placed in a trench. The pipe shall be laid carefully and true to lines and grades on a bed which is uniformly firm throughout its entire length. Any pipe which is not in true alignment, or which shows any undue settlement after being laid or is damaged, shall be taken up and relaid or replaced without extra compensation.

During installation, the asphalt protected pipe shall be handled without damaging the asphalt coating. Any breaks in the bitumen or treatment of the pipe shall be refilled with the type and kind of bitumen used in coating the pipe originally. Perforated pipe shall be placed as indicated on the plans, or directed by the engineer. Pipe shall not be laid on frozen ground.

705-3.4 MORTAR. Mortar shall be mixed in a ratio of one part by volume of Portland cement and two parts by volume of sand. The mortar shall be of the desired consistency for caulking and filling the joints of the pipe, and for making connections to other pipes or to structures. Mortar that is not used within forty-five (45) minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

705-3.5 JOINTS IN CLAY OR CONCRETE PIPE. (a) When open or partly closed joints are required or specified, they shall be constructed as indicated on the plans. The pipe shall be laid with the ends fitted together as designed. If bell and spigot pipe is used hemp, oakum, or mortar, or whichever is specified, shall be placed along the inside bottom quarter of the bell to center the following section of pipe.

1. The open or partly open joints shall be surrounded with granular material meeting requirements of porous backfill No. 2, as indicated on the plans. This backfill shall be placed in such manner that its thickness will be not less than three (3) inches nor more than six (6) inches, unless otherwise shown on the plans.

2. When the original material excavated from the trench is impervious, commercial concrete sand or granular material meeting requirements of porous backfill No. 1 shall surround porous backfill No. 2, as shown on the plans or as directed by the engineer.

3. When the original material excavated from the trench is pervious and suitable, it will be used as backfill in lieu of porous backfill No. 1, when indicated on the plans or as directed by the engineer.

(b) When perforated pipe or cradle invert pipe is specified, granular backfill material No. 2 and No. 1 shall be placed along the full length of the pipe. The position of the granular material shall be as shown on the plans. If the original material excavated from the trench is pervious and suitable, it shall be used in lieu of porous backfill No. 1.

(c) Closed joints for perforated pipe, or for those sections of underdrains which connect the underdrains with sealed storm drain systems, shall be made as follows:

All pipe shall be carefully laid, bell or groove end upgrade, spigot or tongue end fully entered into the adjacent hub, and true to lines and grades given.

The joints of the pipe shall be caulked and filled with the specified mortar. Joints of the pipe shall be thoroughly wet before making the joint.

Before succeeding sections of pipe are laid, the lower portions of the bell or groove of the pipe shall be filled on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. After the pipe is laid, the remainder of the joints shall be solidly filled with mortar and sufficient additional mortar used to form a bead or ring around the outside of the joint. The inside of the joint shall be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap.

705-3.6 BACKFILLING. (a) *Ordinary Earth.* The trenches and excavations shall be backfilled in a reasonable time after the pipes are installed therein, unless other protection of the pipe is directed by the engineer. The backfill material shall be approved by the engineer. Backfill material containing stones or rock exceeding three (3) inches in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds one (1) foot. Backfill material containing rock three (3) inches in diameter or larger shall not be used in trenches under paved areas. Special care shall be taken in placing the backfill. Great care shall be used to obtain thorough compaction under the haunches and along the sides to the top of the pipe.

The backfill shall be placed in loose layers not exceeding six (6) inches in depth under and around the pipe, and not exceeding eight (8) inches over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the engineer, until the trench is completely filled and brought to the elevation as directed. Backfilling shall be done in such a manner as to avoid injurious top or side pressures on the pipe.

In embankments, and for other areas outside of pavements, the backfill shall be compacted to the density as required for embankments in Item P-152 and determined by CAA compaction control tests T-611 for the class of airport involved. Under paved areas, the subgrade and any backfill up to a depth of five (5) feet below the subgrade shall be compacted to the same requirements as given for

subgrades in Item P-152; below a depth of five (5) feet from the subgrade, the compaction shall be as stated for embankments.

(b) *Granular Material.* When granular backfill is required, its placement in the trench and about the pipe shall be as shown on the plans. Special care shall be taken in placing the backfill. The granular backfill shall not contain a damaging amount of foreign matter, nor shall earth from the sides of the trench or from the windrow be allowed to filter into the backfill. When required by the engineer, a template shall be used to properly place and keep separate the two sizes of backfill. The backfill shall be placed in loose layers not exceeding six (6) inches in depth, and compacted by hand and pneumatic tampers to the requirements as given for earth backfill. Backfilling shall be done in such a manner as to avoid injurious top or side pressure on the pipe to cause damage or displacement. The granular backfill shall be made to the elevation in the trench, as shown on the plans.

When porous backfill is to be placed in paved or adjacent areas prior to the completion of grading or subgrade operations, the backfill material shall be placed immediately after laying the pipe. The depth of this granular backfill so placed shall be not less than twelve (12) inches in depth, measured from the top of the underdrain. During subsequent construction operations, this minimum backfill of twelve (12) inches of depth shall not be disturbed until such time as the underdrains are to be completed. When the underdrains are to be completed, the unsuitable material shall be removed until the porous backfill is exposed. That part of the porous backfill which contains objectionable material shall be removed and replaced with suitable material. The cost of removing and replacing any such unsuitable material shall be borne by the contractor.

Whenever a granular subbase blanket course is to be used under pavements, and extends several feet beyond edge of paving to outside edge of underdrain trench, the granular backfill material over the underdrains will be placed in the trench up to an elevation of two (2) inches above the bottom surface of the granular subbase blanket course. Immediately prior to the placing of the granular subbase blanket course, the contractor shall blade this excess trench backfill from top of the trench onto the adjacent subgrade where it can be incorporated into the granular subbase blanket course. Any unsuitable material which remains over the underdrain trench shall be removed and replaced. The subbase material shall be placed to provide clean contact between the subbase material and the underdrain granular backfill material for the full width of the underdrain trench.

705-3.7 CONNECTIONS. Where the plans call for connections to existing or proposed pipe or structures, these connections shall be watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

705-3.8 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus

material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the underdrain.

METHOD OF MEASUREMENT

705-4.1 The footage of pipe to be paid for shall be the number of linear feet of pipe underdrains in place, completed, and approved; measured along the centerline of the pipe from end or inside face of structure, to end or inside face of structure, whichever is applicable. The several classes, types, and sizes shall be measured separately. All fittings shall be included in the footage as typical pipe sections in the pipe line being measured.

705-4.2 The yardage of porous backfill to be paid for shall be the number of cubic yards of porous backfill No. 1 or No. 2, complete in place and accepted; determined from the dimensions given on the plans by typical trench sections indicating the placement of porous backfill, or dimensions ordered by the engineer.

BASIS OF PAYMENT

705-5.1 The footage of pipe, as provided in Section 4.1, shall be paid for at the contract unit price per linear foot for "Pipe Underdrain" of the several classes, types, and sizes, which price and payment shall constitute full compensation for furnishing, hauling, and installing the pipe; for excavation; for earth backfill and compaction; for jointing; for connections to drainage structures; and for all material, labor, equipment, tools, and incidentals necessary to complete the underdrain, as shown on the plans.

705-5.2 The cubic yards of porous backfill No. 1, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Porous Backfill No. 1," which price and payment shall constitute full compensation for porous backfill in place and compacted to the required density; and for all material, labor, equipment, tools, and incidentals necessary to complete the backfill.

705-5.3 The cubic yards of porous backfill No. 2, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Porous Backfill No. 2," which price and payment shall constitute full compensation for porous backfill in place and compacted to the required density; and for all material, labor, equipment, tools, and incidentals necessary to complete the backfill.

Payment will be made under:

- Item D-705-5.1 ----inch Standard Strength Clay Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Perforated Standard Strength Clay Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Cradle Invert Clay Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Standard Nonreinforced Concrete Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Perforated Standard Nonreinforced Concrete Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Perforated Corrugated Metal Pipe Underdrain—per linear foot.
- Item D-705-5.1 ----inch Perforated Bituminous Coated Corrugated Metal Pipe Underdrain—per linear foot.
- Item D-705-5.2 Porous Backfill No. 1—per cubic yard.
- Item D-705-5.3 Porous Backfill No. 2—per cubic yard.

DRAINAGE STRUCTURES

ITEM D-751 MANHOLES, CATCH BASINS, INLETS, AND INSPECTION HOLES

DESCRIPTION

751-1.1 This item shall consist of manholes, catch basin, inlets, inspection holes, and miscellaneous drainage structures constructed of such materials and in accordance with these specifications at the locations and in conformity with the lines, grades, and dimensions shown on the plans, or required by the engineer. These structures shall include the furnishing and installation of such specials and connections to pipes and other structures as may be required to complete the item as shown on the plans. The structures shall provide for the collection of surface water with the exception of manholes and inspection holes which may be designed with closed covers.

MATERIALS

751-2.1 BRICK. The brick shall conform to the requirements of A. A. S. H. O. Specification M-91.

751-2.2 MORTAR. The mortar for brick masonry and similar work shall be composed of one part of Portland cement and two parts of mortar sand by volume. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. The water shall be clean and free from injurious amounts of sewage, oil, acid, strong alkalies, or vegetable matter.

751-2.3 CONCRETE. Plain and reinforced concrete used in structures, connections of pipes with structures, support of structures or frames, shall conform to the requirements of Item P-610.

751-2.4 FRAMES, COVERS, AND GRATINGS. The castings shall conform to one of the following requirements:

(a) Gray iron castings shall meet the requirements of A. A. S. H. O. Specification M-105.

(b) Malleable iron castings shall meet the requirements of A. A. S. H. O. Specification M-106.

(c) Steel castings shall meet the requirements of A. A. S. H. O. Specification M-103.

(d) All castings shall be true to form and dimensions, and shall be free from inclusions of foreign material, casting faults, injurious blow holes, cracks, sponginess, and other defects rendering them unsuitable.

The finished frame and cover or grate shall have the bearing surfaces machined or ground so that there will be no variation that will permit rocking or rattling, and the diameter of the cover or grate shall be such as to fit the frame without wedging.

All grate castings shall be designed for supporting a uniform load of one hundred and twenty (120) pounds per square inch, one hundred (100) pounds per square inch, or eighty (80) pounds per square inch, respectively. The open areas of the gratings shall be as designated on the plans, and the design loading shall be as specified.

Each frame and cover or grate unit shall be provided with fastening units. For a rectangular casting, the fastening units shall be at each end. For a circular casting, there shall be at least four (4) fastening units so that the grating or cover cannot work loose. All castings shall be thoroughly cleaned and given two coats of approved bituminous paint.

751-2.5 STEPS. The steps or ladder bars shall be gray or malleable cast iron, galvanized wrought iron, or galvanized steel. The bars shall be smoothly rolled and free from slivers, depressions, or seams. The steps shall be of the size, length, and shape as shown on the plans. The steps which are not galvanized shall be given a coat of bituminous paint when directed.

751-2.6 STEEL GRATES AND FRAMES. Steel for grates and frames shall conform to the requirements for structural steel of the A. A. S. H. O. Specification M-94. The grates and frames shall be of the design and dimensions as shown on the plans and consisting of bars with the size and spacing indicated. The grates shall be electro-pressure welded. The frames shall be fabricated by welding angles, other shapes, or plates of suitable size to hold the grates. The grates and frames, after fabrication, shall be galvanized to meet the requirements of A. A. S. H. O. Specification M-111. The grates shall be designed to support the loading per square inch as given in Section 2.4, paragraph (d), for castings, or as specified. Each grate and frame unit shall be provided with fastening units to prevent it from being dislodged by traffic but which will allow easy removal for access to the structure.

CONSTRUCTION METHODS

751-3.1 UNCLASSIFIED EXCAVATION. (a) The contractor shall do all excavation for structures and structure footings to the lines and grades or elevations, shown on the plans, or as staked by the engineer. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only; and the engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

(b) Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface

392 751. MANHOLES, CATCH BASINS, AND INLETS

either level, stepped, or serrated, as directed by the engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing is to be placed.

(c) The contractor shall do all bracing, sheathing, or shoring necessary to perform and protect the excavation and the structure; also, as required for safety or to conform to governing laws. The cost of bracing, sheathing, or shoring shall be included in the unit price bid for the structure.

(d) Unless otherwise provided, bracing, sheathing, or shoring involved in the construction of this item shall be removed by the contractor after the completion of the structure. Removal shall be effected in such a manner as not to disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for the structure.

(e) After each excavation is completed, the contractor shall notify the engineer to that effect; and concrete or reinforcing steel shall be placed after the engineer has approved the depth of the excavation and the character of the foundation material.

751-3.2 BRICK STRUCTURES. (a) *Foundations.* A prepared foundation shall be placed for all brick structures after the foundation excavation is completed and accepted. Unless otherwise specified, the base shall consist of reinforced concrete mixed, prepared, and placed in accordance with the requirements of Item P-610. The foundation shall be built to the correct elevation, and shall be finished to cause the least possible resistance to flow.

(b) *Laying Brick.* All brick shall be thoroughly clean; the bed which is to receive the brick shall be thoroughly cleaned and wetted with water before placing mortar thereon. All brick shall be laid in freshly made mortar composed of one part by volume of Portland cement and two parts by volume of sand with the possible addition of hydrated lime in an amount not to exceed fifteen (15) percent by volume of the cement used. The brick shall be laid in courses using the shoved-joint method so as to thoroughly bond them into the mortar and always with the joints completely filled with mortar. The brick shall be laid in a workmanlike manner, and true to the lines and grades indicated on the plans. The arrangement of headers and stretchers shall be such as will thoroughly bond the masonry; and unless otherwise indicated, brick masonry shall be of alternate headers and stretchers with consecutive courses breaking joints. The courses shall be laid continuously with joints broken or alternating evenly with the joints in the preceding courses. The joints shall be not less than one-fourth ($\frac{1}{4}$) inch nor not more than one-half ($\frac{1}{2}$) inch in thickness. Face joints shall be neatly struck, using the weather joint. All joints shall be finished properly as the laying of brick progresses.

No spalls or bats shall be used except in shaping around irregular openings or connections or when unavoidable to finish out a course,

in which case a full brick shall be used at the corner and the bat in the interior of the course.

In case any brick is moved, or a joint broken during laying, the brick shall be taken up, the mortar thoroughly cleaned from the brick, bed, and joints, and the brick relaid in fresh mortar. In hot and dry weather, or when directed, the brick masonry shall be protected and kept moist for a period of at least forty-eight (48) hours after laying of the brick.

The inside and outside surfaces of brick masonry shall be neatly plastered with mortar to a thickness of not less than one-half ($\frac{1}{2}$) inch, and the mortar shall be finished to a true and uniform surface. The mortar shall be protected and kept moist for forty-eight (48) hours after completion.

Brick masonry shall not be constructed in freezing weather or when bricks contain frost, except by written permission of the engineer and subject to such conditions for protection against freezing.

751-3.3 CONCRETE STRUCTURES. The structures shall be constructed of concrete, built on prepared foundations, conforming to the dimensions and form indicated on the plans. The construction shall conform to the methods, forms, mixture, placement, and curing, as specified in Item P-610. Any reinforcement required shall be of the kind, type, and size, and shall be furnished, located, spaced, bent, and fastened as indicated on the plans; it shall be approved by the engineer before the concrete is poured.

All invert channels shall be constructed and shaped accurately so as to be smooth, uniform, and cause minimum resistance to flow. The interior bottom shall be sloped downward toward the outlet.

751-3.4 INLET AND OUTLET PIPES. Inlet and outlet pipes shall extend through the walls of the structures for a sufficient distance beyond the outside surface to allow for connections, but shall be cut off flush with the wall on the inside surface unless otherwise directed. Concrete or brick and mortar shall be constructed around the pipes so as to prevent leakage and form a neat connection.

751-3.5 PLACEMENT AND TREATMENT OF CASTINGS, FRAMES, AND FITTINGS. All castings, frames, and fittings shall be placed in the positions indicated on the plans or as directed by the engineer, and shall be set true to line and to correct elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place and position before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

When frames or fittings are to be placed upon previously constructed masonry, the bearing surface or masonry shall be brought true to line and grade and present an even bearing surface in order that the entire face or back of the unit will come in contact with the masonry. The unit shall be set in mortar beds or anchored to the masonry, as indicated on the plans or as directed and approved by the engineer. All units shall set firm and secure.

After the frames or fittings have been set in final position, and the concrete or mortar has been allowed to harden for seven (7) days, the grates or covers shall be placed and fastened down.

751-3.6 INSTALLATION OF STEPS. The steps shall be installed as indicated on the plans, or as directed by the engineer. When the steps are to be set in concrete they shall be placed and secured in position before the concrete is poured. When the steps are installed in brick masonry they shall be placed as the masonry is being built. The steps shall not be disturbed or used until the concrete or mortar has hardened for at least seven (7) days. After this period has elapsed, the steps shall be cleaned and painted, unless they have been galvanized.

751-3.7 BACKFILLING. (a) After a structure has been completed, the area around it shall be filled with approved material, in horizontal layers not to exceed eight (8) inches in loose depth, and compacted to the density specified. The fill shall be made to the elevation shown on the plans, or as directed by the engineer.

(b) No backfilling shall be placed against any structure until permission is given by the engineer. In the case of concrete, such permission preferably shall not be given until the concrete has been in place fourteen (14) days, or until tests made by the laboratory, under the supervision of the engineer, establish that the concrete has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor. Adequate provisions shall be made for thorough drainage.

(c) Fill placed shall be deposited all around a structure at the same time and to approximately the same elevation. Especial care shall be taken to prevent any wedging action against the structure, and all slopes bounding or within the areas to be backfilled will be stepped or serrated to prevent wedge action.

(d) All backfill shall be compacted to the density as required in Item P-152, and as determined by CAA compaction control tests T-611 for the class of airport involved.

(e) Backfill shall not be measured for direct payment. Performance of this work is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure involved.

751-3.8 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure.

METHOD OF MEASUREMENT

751-4.1 The number of brick manholes, catch basins, inlets, or inspection holes shall be counted for each type and size of structure and listed as the number of units complete in place and accepted.

751-4.2 The number of concrete manholes, catch basins, inlets, or inspection holes shall be counted for each type and size of structure and listed as the number of units complete in place and accepted.

751-4.3 Manholes, catch basins, inlets, or inspection holes shall be measured for payment by the vertical foot for each type and size of structure and for brick or concrete construction, complete, in place, and accepted. The number of vertical feet for a structure shall be defined as the vertical distance to the nearest one tenth of a foot from the bottom of the footing to the top of the rim. The units of structures of approximately equal size shall be divided into groups by depth measurements between the following limiting figures, as for instance: 0 to 6 feet; 6 feet to 10 feet; 10 feet to 12 feet, etc.

BASIS OF PAYMENT

751-5.1 The number of units of brick structures, determined as provided in Section 4.1, shall be paid for at the contract unit price per each for "Brick Manholes, Catch Basins, Inlets, or Inspection Holes," respectively, as called for in the bid schedule, which prices and payment shall constitute full compensation for furnishing all materials; for placing and finishing; for all connections to drainage pipe; for all excavation and hauling; for all backfilling; for setting and anchoring any frame, grate, cover, or fitting necessary to complete structure; for finishing flow line; for placing steps; for plastering brick surfaces as required; and for all labor, equipment, tools, and incidentals necessary to complete the units.

751-5.2 The number of units of concrete structures, determined as provided in Section 4.2, shall be paid for at the contract unit price per each for "Concrete Manholes, Catch Basins, Inlets, or Inspection Holes," respectively, as called for in the bid schedule, which prices and payment shall constitute full compensation for the concrete; for furnishing all materials; for placing and finishing; for all reinforcing; for all connections to drainage pipe; for all excavation and hauling; for all backfilling; for setting and anchoring any frame, grate, cover, or fitting necessary to complete structure; for finishing flow line; for placing steps; and for all labor, equipment, tools, and incidentals necessary to complete the units.

751-5.3 The linear feet of manholes, catch basins, inlets, or inspection holes, as provided in Section 4.3, for either brick or concrete

construction, shall be paid for at the contract unit price per vertical foot for "Manholes, Catch Basins, Inlets, or Inspection Holes" as called for in the bid schedule, which prices and payment shall constitute full compensation for furnishing all materials; for placing and finishing; for all reinforcing; for all connections to drainage pipe; for all excavation and hauling; for all backfilling; for setting and anchoring any frame, grate, cover, or fitting necessary to complete structure; for finishing flow line; for placing steps; for plastering brick surfaces where applicable; for concrete where applicable; and for all labor, equipment, tools, and incidentals necessary to complete the units.

Payment will be made under:

- Item D-751-5.1 Units of Brick Structures (Manholes, Catch Basins, Inlets, or Inspection Holes)—per each.
- Item D-751-5.2 Units of Concrete Structures (Manholes, Catch Basins, Inlets, or Inspection Holes)—per each.
- Item D-751-5.3 Vertical Linear Feet of Brick or Concrete Structures (Manholes, Catch Basins, Inlets, or Inspection Holes)—per vertical foot.

BASIS OF PAYMENT

751-5.1 The number of units of brick structures determined as provided in Section 4.1 shall be paid for at the contract unit price per each for "Brick Manholes, Catch Basins, Inlets, or Inspection Holes", respectively, as called for in the bid schedule, which prices and payment shall constitute full compensation for furnishing all materials; for placing and finishing; for all connections to drainage pipe; for all excavation and hauling; for all backfilling; for setting and anchoring any frame, grate, cover, or fitting necessary to complete structure; for finishing flow line; for placing steps; for plastering brick surfaces as required; and for all labor, equipment, tools, and incidentals necessary to complete the units.

751-5.2 The number of units of concrete structures, determined as provided in Section 4.2, shall be paid for in the contract unit price per each for "Concrete Manholes, Catch Basins, Inlets, or Inspection Holes", respectively, as called for in the bid schedule, which prices and payment shall constitute full compensation for the concrete; for finishing all materials; for placing and finishing; for all connections to drainage pipe; for all excavation and hauling; for all backfilling; for setting and anchoring any frame, grate, cover, or fitting necessary to complete structure; for finishing flow line; for placing steps; and for all labor, equipment, tools, and incidentals necessary to complete the units.

751-5.3 The linear feet of manholes, catch basins, inlets, or inspection holes, as provided in Section 4.3, for either brick or concrete

ITEM D-752 CONCRETE CULVERTS, HEADWALLS, AND MISCELLANEOUS DRAINAGE STRUCTURES

DESCRIPTION

752-1.1 This item shall consist of concrete, both plain and reinforced, culverts, headwalls, and miscellaneous drainage structures constructed in accordance with these specifications at the locations and in conformity with the lines, grades, and dimensions shown on the plans or required by the engineer.

MATERIALS

752-2.1 CONCRETE. Plain and reinforced concrete shall meet the requirements of Item P-610.

752-2.2 BACKFILLING. The material used for backfill shall be selected material from the excavation or borrow. All excavated material, so far as suitable, shall be utilized as backfill or embankment.

CONSTRUCTION METHODS

752-3.1 UNCLASSIFIED EXCAVATION. (a) Trenches and foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the plans or as staked by the engineer. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only; and the engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

(b) Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing steel is to be placed.

(c) The contractor shall do all bracing, sheathing, or shoring necessary to perform and protect the excavation and the structure; also as required for safety or to conform to governing laws. The cost of brac-

ing, sheathing, or shoring shall be included in the unit price bid for excavation.

(d) Unless otherwise provided, bracing, sheathing, or shoring involved therewith shall be removed by the contractor after the completion of the structure. Removal shall be effected in such manner as not to disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for excavation.

(e) After each excavation is completed, the contractor shall notify the engineer to that effect, and concrete or reinforcing steel shall be placed after the engineer has approved the depth of the excavation and the character of the foundation material.

752-3.2 CONCRETE. Plain or reinforced concrete construction methods shall conform to the requirements of Item P-610.

752-3.3 BACKFILLING. (a) After a structure has been completed, the areas around the foundation shall be filled with approved material, in horizontal layers not over eight (8) inches in loose depth, and compacted to the density specified.

(b) No backfilling shall be placed against any structure until permission is given by the engineer. In the case of concrete, such permission preferably shall not be given until the concrete has been in place fourteen (14) days, or until tests made by the laboratory, under the supervision of the engineer, establish that the concrete has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor. Adequate provision shall be made for thorough drainage. Drains shall be placed at weep holes.

(c) Fill placed around concrete culverts shall be deposited on both sides at the same time and to approximately the same elevation. Especial care shall be taken to prevent any wedging action against the structure, and all slopes bounding or within the areas to be backfilled will be stepped or serrated to prevent wedge action.

(d) In backfilling against the structures the bed for a backfill shall be so prepared and serrated, and the backfill shall be so built up in horizontal layers, that at all times there shall be a horizontal berm of compacted material behind the structure for a distance at least equal to the height of the section to be backfilled against, except insofar as undisturbed material obtrudes upon this area. Each layer of this berm will be compacted to a density specified for the area. This compaction will be obtained by the use of suitable mechanical tampers or equipment.

(e) All backfill shall be compacted to the density as required in Item P-152, and as determined by CAA compaction control tests T-611 for the class of airport involved.

(f) Backfill shall not be measured for direct payment. Performance of this work under the contract is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for "Unclassified Excavation for Structures."

752-3.4 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure.

METHOD OF MEASUREMENT

752-4.1 The yardage of unclassified excavation for structures to be paid for shall be the number of cubic yards, measured in original position, of material excavated and in conformity with the plans, or as directed by the engineer; but in no case shall any yardage be included in the measurement for payment which is outside of a volume bounded by vertical planes eighteen (18) inches outside of and parallel to the neat lines of the footings. The cross-sectional area measured shall not include water or other liquid but shall include mud, muck, or similar semisolid material not resulting from construction operations and which cannot be pumped or drained away. The measurement shall not include the yardage of any excavation performed prior to the taking of elevations and measurements of the undisturbed ground.

752-4.2. The yardage of concrete to be paid for shall be the number of cubic yards of concrete, complete in place and accepted. In computing the yardage of concrete for payment, the dimensions used shall be those shown on the plans or ordered by the engineer. No measurements or other allowances will be made for forms, false work, cofferdams, pumping, bracing, expansion joints, or finishing of the concrete. No deductions in yardage will be made for the volumes of reinforcing steel or embedded items.

752-4.3 The poundage of reinforcing steel to be paid for shall be the calculated theoretical number of pounds placed as shown on the plans, complete in place and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars, as the case may be, of equal nominal size. If so indicated on the plans, the poundage to be paid for shall include the weight of metal pipes and drains, metal conduits and ducts, or similar materials indicated and included.

BASIS OF PAYMENT

752-5.1 The yardage of unclassified excavation for structures, measured as provided in Section 4.1, shall be paid for at the contract unit price per cubic yard for "Unclassified Excavation for Structures,"

which price and payment shall constitute full compensation for all excavation and hauling; for bedding and backfilling for culverts and other structures excepting pipe; for preparing and completing of subgrade and shoulders; for any conserving of cushion and topping material; for finishing, rounding, and warping of slopes; for clearing and grubbing of any description necessary to the completion of this item; and for all labor, equipment, tools, and incidentals necessary to complete the item.

752-5.2 The yardage of concrete, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Concrete" as called for in the bid schedule, which price and payment shall constitute full compensation for the concrete; for furnishing all materials; for placing and finishing; for furnishing and installing all joints, joint fillers, drains, ducts, etc.; for forms and false work; for curing and protection; and for all labor, equipment, tools, and incidentals necessary to complete the item.

752-5.3 The poundage of reinforcing steel, determined as provided in Section 4.3, shall be paid for at the contract unit price per pound for "Reinforcing Steel" as called for in the bid schedule, which price and payment shall constitute full compensation for the furnishing and placing of all materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item D-752-5.1 Unclassified Excavation for Structures—per cubic yard.

Item D-752-5.2 Structure Concrete—per cubic yard.

Item D-752-5.3 Reinforced Steel—per pound.

ITEM D-753 CEMENT RUBBLE MASONRY CULVERTS, HEADWALLS, AND MISCELLANEOUS DRAINAGE STRUCTURES

DESCRIPTION

753-1.1 This item shall consist of cement rubble masonry culverts, headwalls, and miscellaneous drainage structures constructed in accordance with these specifications at the locations and in conformity with the lines, grades, and dimensions shown on the plans, or required by the engineer.

MATERIALS

753-2.1 STONE. The stone shall be clean, hard, and of a kind known to be durable, and shall be subject to the engineer's approval. It shall be preferably native to the vicinity of the work. (Vicinity of the work shall be understood to mean within a radius of approximately ten (10) miles.)

(a) *Sizes and Shapes.* The individual face stones shall be furnished in the sizes indicated on the drawings.

Unless other sizes are shown on the drawings, stones shall have thicknesses of not less than five (5) inches, widths of not less than one and one-half ($1\frac{1}{2}$) times their respective thicknesses, and lengths of not less than one and one-half ($1\frac{1}{2}$) times their respective widths. Each stone shall be of good shape and be free from depressions and projections that might weaken or prevent it from being properly bedded. At least fifty (50) percent of the total volume of the masonry shall be of stones having a volume at least one cubic foot each. When a definite dimension of a stone is shown on the plans, the stone shall be of the size shown. There shall be a variety in the sizes of face stones and, as a general rule, not more than ten (10) percent shall be equal in size.

(b) *Dressing.* The stone shall be hammer-dressed to remove any thin or weak portions. Face stones shall be dressed to provide bed and joint lines that do not vary more than one and one-half ($1\frac{1}{2}$) inches from true lines, and to insure the meeting of bed and joint lines without the rounding of the corners of the stones in excess of one and one-half ($1\frac{1}{2}$) inches in radius. Bed surfaces of face stones shall be approximately normal to the faces of the stones for about two (2) inches, and from this point may depart from a normal plane not to exceed two (2) inches in twelve (12) inches.

Stratification in arch ring stones shall be parallel to the radial joints, and in other stones shall be parallel to the bed joints.

(c) *Finish for Exposed Faces.* The maximum and minimum projections of rock faces beyond the pitch lines shall not vary from each other by more than two (2) inches.

753-2.2 QUARRY OPERATIONS. Quarry operations and delivery of stone to the point of use shall be organized so as to insure keeping deliveries well ahead of masonry operations. A sufficiently large stock of stone, of the kinds being used in the work, shall be kept on the site at all times to permit adequate selection of stone by the masons.

753-2.3 MORTAR. Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type 1. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. The water shall be clean and free from injurious amounts of sewage, oil, acid, strong alkalies, or vegetable matter.

The mortar for the masonry shall be composed of one (1) part cement and two (2) parts of mortar sand by volume and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Mortar shall be mixed only in those quantities required for immediate use. Unless an approved mortar mixing machine is used, the mortar sand and cement shall be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains the proper consistency. Mortar that is not used within forty-five (45) minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

753-2.4 CONCRETE. Plain and reinforced concrete for footings shall meet the requirements of Item P-610.

753-2.5 BACKFILLING. The material used for backfill shall be selected material from the excavation or borrow. All excavated material, so far as suitable, shall be utilized as backfill or embankment.

CONSTRUCTION METHODS

753-3.1 UNCLASSIFIED EXCAVATION. (a) Trenches and foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the plans, or as staked by the engineer. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only and the engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

(b) Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped, or serrated, as directed by the engineer. All

seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall not be made until just before the concrete or reinforcing steel is to be placed.

(c) The contractor shall do all bracing, sheathing, or shoring necessary to perform and protect the excavation and the structure; also, as required for safety or to conform to governing laws. The cost of bracing, sheathing, or shoring shall be included in the unit price bid for excavation.

(d) Unless otherwise provided, bracing, sheathing, or shoring involved therewith shall be removed by the contractor after the completion of the structure. Removal shall be effected in such manner as not to disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for excavation.

(e) After each excavation is completed, the contractor shall notify the engineer to that effect and concrete or reinforcing steel shall be placed after the engineer has approved the depth of the excavation and the character of the foundation material.

753-3.2 CONCRETE. Plain or reinforced concrete construction of footings shall conform to the requirements of Item P-610.

753-3.3 SELECTION AND PLACING OF STONE. When the masonry is to be placed directly on the bottom of the excavation, the prepared foundation bed for the work shall be firm and normal to, or in steps normal to, the face of the wall, and shall have been approved by the engineer before any stone is placed. Large flat stones shall be used in the bottom course, and selected stones shall be placed in the corners. When the masonry is to be placed on concrete footings, the bearing surface of this concrete shall be cleaned thoroughly and wetted immediately before the mortar bed is spread.

All masonry shall be constructed by experienced workmen. Face stones shall be set in random bond so as to produce the effect shown on the drawings or approved by the engineer.

Care shall be taken to prevent the bunching of small stones or stones of the same size. When weathered or colored stones, or those of varying texture are being used, care shall be exercised to distribute the various kinds of stones uniformly throughout the exposed faces of the work. Large stones shall be used for the bottom courses, and large, selected stones shall be used in the corners. In general, the stones shall decrease in size from the bottom to the top of work.

All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joints shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.

The stones shall be so handled as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. The rolling or turning of stones on the wall will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar.

753-3.4 BACKFILLING. (a) After a structure has been completed, the areas around the foundation shall be filled with approved material, in horizontal loose layers not over eight (8) inches in depth, and compacted to the density specified.

(b) No backfilling shall be placed against any structure until permission is given by the engineer. In the case of masonry, such permission preferably shall not be given until the mortar has been in place fourteen (14) days, or until the masonry has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor. Adequate provision shall be made for thorough drainage. Drains shall be placed at weep holes.

(c) Fill placed around box culverts shall be deposited on both sides at the same time and to approximately the same elevation. Especial care shall be taken to prevent any wedging action against the structure and all slopes bounding or within the areas to be backfilled will be stepped or serrated to prevent wedge action.

(d) In backfilling against the structures, the bed for a backfill shall be so prepared and serrated, and the backfill shall be so built up in horizontal layers that at all times there shall be a horizontal berm of compacted material behind the structure for a distance at least equal to the height of the section to be backfilled against, except insofar as undisturbed material obtrudes upon this area. Each layer of this berm will be compacted to a density specified for the area. This compaction will be obtained by the use of suitable mechanical tampers or equipment.

(e) All backfill shall be compacted to the density as required in Item P-152, and as determined by CAA compaction control tests T-611, for the class of airport involved.

(f) Backfill shall not be measured for direct payment. Performance of this work under the contract is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for "Unclassified Excavation for Structures."

753-3.5 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure.

METHOD OF MEASUREMENT

753-4.1 The yardage of unclassified excavation for structures to be paid for shall be the number of cubic yards, measured in original position, of material excavated acceptably and in conformity with the plans, or as directed by the engineer; but in no case shall any yardage be included in the measurement for payment which is outside of a volume bounded by vertical planes eighteen (18) inches outside of and parallel to the neat lines of the footings. The cross-sectional area measured shall not include water or other liquid but shall include mud, muck, or similar semisolid material not resulting from construction operations and which cannot be pumped or drained away. The measurement shall not include the yardage of any excavation performed prior to the taking of elevations and measurements of the undisturbed ground.

753-4.2 The yardage of concrete to be paid for shall be the number of cubic yards of concrete complete in place, and accepted. In computing the yardage of concrete for payment, the dimensions used shall be those shown on the plans or ordered by the engineer. No measurements or other allowances will be made for forms, false work, cofferdams, pumping, bracing, expansion joints, or finishing of the concrete. No deductions in yardage will be made for the volumes of reinforcing steel or embedded items.

753-4.3 The poundage of reinforcing steel to be paid for shall be the calculated theoretical number of pounds placed as shown on the plans complete, in place, and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars, as the case may be, of equal nominal size. If so indicated on the plans, the poundage to be paid for shall include the weight of metal pipes and drains, metal conduits, and ducts or similar materials indicated and included.

753-4.4 The yardage of cement rubble masonry to be paid for shall be the number of cubic yards of cement rubble masonry complete in place, and accepted. Projections extending beyond the faces of the walls shall not be included. In computing the yardage for payment, the dimensions used shall be those shown on the plans, or ordered in writing by the engineer. No deductions will be made for weep holes, drain pipe, or other openings of less than two (2) square feet in area.

BASIS OF PAYMENT

753-5.1 The yardage of unclassified excavation for structures, measured as provided in Section 4.1, shall be paid for at the contract unit price per cubic yard for "Unclassified Excavation for Structures," which price and payment shall constitute full compensation for all

excavation and hauling; for bedding and backfilling for culverts and other structures excepting pipe; for preparing and completing of subgrade and shoulders; for any conserving of cushion and topping material; for finishing, rounding, and warping of slopes; for clearing and grubbing of any description necessary to the completion of this item; and for all labor, equipment, tools, and incidentals necessary to complete the item.

753-5.2 The yardage of concrete, determined as provided in Section 4.2, shall be paid for at the contract unit price per cubic yard for "Concrete" as called for in the bid schedule, which price and payment shall constitute full compensation for the concrete; for furnishing all materials; for placing and finishing; for furnishing and installing all joints, joint fillers, drains, ducts, etc.; for forms and false work; for curing and protection; and for all labor, equipment, tools, and incidentals necessary to complete the item.

753-5.3 The poundage of reinforcing steel, determined as provided in Section 4.3, shall be paid for at the contract unit price per pound for "Reinforcing Steel," as called for in the bid schedule, which price and payment shall constitute full compensation for the furnishing and placing of all materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

753-5.4 The yardage of cement rubble masonry, as determined in Section 4.4, shall be paid for at the contract unit price per cubic yard for "Cement Rubble Masonry," which price and payment shall be full compensation for furnishing and placing all materials; for mortar; for masonry; and for all labor, equipment, tools, and incidentals necessary to complete the item, except foundation excavation, or concrete footings.

Payment will be made under:

Item D-753-5.1 Unclassified Excavation for Structures—per cubic yard.

Item D-753-5.2 Structure Concrete for Footings—per cubic yard.

Item D-753-5.3 Reinforcing Steel—per pound.

Item D-753-5.4 Cement Rubble Masonry—per cubic yard.

ITEM D-754 CONCRETE PAVED GUTTERS, DITCHES, AND FLUMES

DESCRIPTION

754-1.1 This item shall consist of gutters, ditches, or flumes paved with Portland cement concrete, constructed in accordance with these specifications at the locations and in conformity with the form, dimensions, designs, and to the lines and grades shown on the plans or required by the engineer.

MATERIALS

754-2.1 CONCRETE. Plain and reinforced concrete shall meet the requirements of Item P-501, Class "B" concrete, unless otherwise indicated on the plans.

754-2.2 JOINTS. Joint filler materials and premoulded joint material shall conform to Item P-501.

CONSTRUCTION METHODS

754-3.1 PREPARING SUBGRADE. Excavation shall be made to the required width and depth, and the subgrade upon which the item is to be built shall be compacted to a firm uniform grade. All soft and unsuitable material shall be removed and replaced with suitable approved material. When required, a layer of approved granular material, having the compacted thickness as shown on the plans, shall be placed to form a subbase. The underlying course shall be checked and accepted by the engineer before placing and spreading operations are started.

754-3.2 PLACING. The forms to hold and for finishing the concrete, the mixing, placing, finishing, and curing of the concrete shall be as provided under Item P-501 and in accordance with the following requirements:

The concrete shall be placed in the forms in layers not to exceed six (6) inches, and to the final depth required. The concrete shall be tamped and spaded until it is consolidated and mortar entirely covers and forms the top surface. The surface of the concrete shall be floated smooth and the edges rounded to the radii shown on the plans. Before the concrete is given the final finishing, the surface shall be tested with a 10-foot straightedge, and any irregularities of more than one-quarter ($\frac{1}{4}$) inch in ten (10) feet shall be eliminated.

The concrete shall be placed with dummy-grooved joints not to exceed twenty-five (25) feet apart, except where shorter lengths are

necessary for closures, but no section shall be less than four (4) feet long.

Expansion joints of the type called for in the plans shall be constructed to replace a dummy groove at a spacing of approximately one hundred (100) feet. When the gutter is placed next to a concrete pavement, expansion joints in the gutter shall be located opposite expansion joints in the pavement. When a gutter abuts a pavement or other structure, an expansion joint shall be placed between the gutter and the other structure.

Forms shall not be removed within twenty-four (24) hours after concrete has been placed. Minor defects shall be repaired with mortar containing one part cement and two parts fine aggregate.

The operations of depositing, compacting, and finishing the item shall be conducted in a workmanlike manner to build a satisfactory structure. If any section of concrete is found to be porous, other than minor defects plastered, or is otherwise defective, it shall be removed and replaced by the contractor without additional compensation.

754-3.3 BACKFILLING. After the concrete has set sufficiently, the spaces adjacent to the structure shall be refilled to the required elevation with material called for on the plans and compacted by mechanical equipment to at least ninety (90) percent density, as determined by CAA compaction control tests T-611 for the class of airport involved.

754-3.4 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure.

METHOD OF MEASUREMENT

754-4.1 The footages to be paid for (structures of uniform cross section) shall be the number of linear feet, measured along the surface profile, of typical sections as shown on the plans for gutters, flumes, or paved ditches measured in place, completed and accepted.

754-4.2 The yardage to be paid for (irregular areas) shall be the number of square yards of concrete, measured along the surface profile, for all special sections and areas of irregular widths, as shown on the plans for gutters, flumes, or paved ditches, measured in place, completed and accepted.

BASIS OF PAYMENT

754-5.1 The linear footage of gutters, ditches, or flumes, as provided for in paragraph 4.1, shall be paid for at the contract unit price per linear foot for "Concrete Paved Gutters, Ditches or Flumes," as called for in the bid schedule, which price and payment shall constitute full compensation for furnishing and placing all materials; for concrete; for reinforcing steel and expansion joint material; for forms, drainage openings, excavation, and subgrade; for refilling, tamping, and disposal of surplus materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

754-5.2 The square yardage, measured as described in paragraph 4.2, shall be paid for at the contract unit price per square yard for "Concrete Paved Gutters, Ditches or Flumes," as called for in the bid schedule, which price and payment shall constitute full compensation for furnishing and placing all materials; for concrete; for reinforcing steel and expansion joint material; for forms, drainage openings, excavation, and subgrade; for refilling, tamping, and disposal of surplus materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item D-754-5.1 Concrete Paved Gutters, Ditches, or Flumes—
per linear foot.

Item D-754-5.2 Concrete Paved Gutters, Ditches, or Flumes—
per square yard.

ITEM D-755 GROUTED RUBBLE GUTTERS, DITCHES, AND FLUMES

DESCRIPTION

755-1.1 This item shall consist of grouted rubble gutters, ditches, or flumes, constructed on a prepared bed in accordance with these specifications at the locations and in conformity with the lines, grades, and dimensions shown on the plans, or required by the engineer.

MATERIALS

755-2.1 RUBBLE STONE. The stones shall be approved, sound, durable rubble stones, not less than six (6) inches and not more than eight (8) inches in thickness, with approximately flat top surfaces, with widths of not less than two (2) inches and lengths not less than six (6) inches. All stones shall be inspected before and after being laid. All rejected material shall be removed immediately from the work.

755-2.2 GROUT. The cement grout for filling the spaces between the stones shall be composed of one part Portland cement and two parts of fine aggregate by volume. The Portland cement shall conform to the requirements of A. S. T. M. Designation C-150, Type I. The sand shall conform to the requirements of A. A. S. H. O. Specification M-45. The water shall be clean and free from injurious amounts of sewage, oil, acid, strong alkalies, or vegetable matter.

CONSTRUCTION METHODS

755-3.1 PREPARING SUBGRADE. Excavation shall be made to the required width and depth, and the subgrade upon which the item is to be built shall be compacted to a firm uniform grade. All soft and unsuitable material shall be removed and replaced with suitable approved material. When required, a layer of approved granular material, having the compacted thickness as shown on the plans, shall be placed to form a subbase. The underlying course shall be checked and accepted by the engineer before placing operations are started.

755-3.2 PLACING. The stones shall be bedded in the foundation in straight rows with each stone perpendicular to the finished surface. The stones shall be set in close contact, their flat surfaces up and their longest dimension at right angles to the centerline of the gutter, ditch, or flume. They shall break joints satisfactorily, and there shall be no interstices exceeding one (1) inch in width.

The stones shall be rammed thoroughly until the surface is firm and conforms to the finished surface in grade, alignment, and cross section.

Any sections having an irregular or uneven surface shall be taken up and relaid satisfactorily.

755-3.3 GROUTING. After the stones have been rammed into place and the surface is satisfactory, the spaces or voids between and around the stones shall be filled with cement grout. The cement grout shall be poured and broomed into the spaces between the stones, this operation being continued until the grout remains flush with the tops of the stones. The grout shall be of such consistency that it will flow readily into the spaces between the stones, but it must not be so wet that the solid matter separates from the water.

755-3.4 BACKFILLING. After the grout has set sufficiently, the spaces adjacent to the structure shall be refilled to the required elevation with material called for on the plans and compacted by mechanical equipment to at least ninety (90) percent density, as determined by CAA compaction control tests T-611 for the class of airport involved.

755-3.5 CLEANING AND RESTORATION OF SITE. After the backfill is completed, the contractor shall dispose of all surplus material, dirt, and rubbish from the site. Surplus dirt may be deposited in embankment, shoulders, or as ordered by the engineer. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition.

After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the entire site free, clear, and in good condition.

Performance of the work described in this section is not payable directly, but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit price for the structure.

METHOD OF MEASUREMENT

755-4.1 The yardage to be paid for shall be the number of square yards (widths and lengths measured along the surface profile) of grouted rubble gutters, ditches, or flumes, complete in place and accepted.

BASIS OF PAYMENT

755-5.1 The yardage, as determined in paragraph 4.1, shall be paid for at the contract unit price per square yard for "Grouted Rubble Gutters, Ditches, or Flumes," as called for in the bid schedule, which price and payment shall constitute full compensation for furnishing and placing all materials; for excavating and refilling below the finished grade of the grouted rubble gutter, flume, or ditch; for all tamping; for all grouting; for disposing of surplus materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item D-755-5.1 Grouted Rubble Gutters, Ditches, or Flumes—
per square yard.

DIVISION IV—TURFING

ITEM T-901 SEEDING

DESCRIPTION

901-1.1. This item shall consist of preparing the ground surface, furnishing and applying lime and fertilizer, furnishing and sowing seed, compacting, establishing, and repairing in accordance with this specification at the locations shown on the plans or as directed by the engineer.

MATERIALS

901-2.1 SEED. The seed or seed mixture to be furnished, and the minimum percentage by weight of pure live seed of each species in each lot of seed, and the maximum percentage of weed seed shall be as stated in the special provisions. When the total percentage of pure live seed furnished is higher than the minimum required, the ratio of seed of the named species shall be approximately the same as that stated in the special provisions. All seed used shall be labeled in accordance with U. S. Department of Agriculture "Rules and Regulations Under the Federal Seed Act" in effect on the date of invitation for bids. All seed shall be furnished in standard containers, unless exception is granted by the engineer. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be acceptable.

901-2.2. LIME. Lime shall be ground limestone containing not less than eighty-five (85) percent of total carbonates, and shall be ground to such fineness that ninety (90) percent will pass through a No. 20 mesh sieve and fifty (50) percent will pass through a No. 100 mesh sieve. Coarser material will be acceptable, providing the rates of application are increased to provide not less than the minimum quantities stated in the special provisions on the basis of the two sieve requirements above.

901-2.3 FERTILIZER. Fertilizers shall be commercial carriers of available plant food elements or combinations thereof, either as inorganic or organic materials, as stated in the special provisions, and shall conform to the applicable State fertilizer laws. The fertilizer shall be uniform in composition, dry, and free-flowing material in condition for application by suitable equipment. The fertilizer shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Any

fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable.

901-2.4 SOIL FOR REPAIRS. The soil for fill and topsoiling of areas to be repaired shall be at least of equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent sowing, compacting, or establishing, and shall be approved by the engineer before being placed.

901-2.5 INSPECTION AND TESTS. (a) *Seed.* Duplicate signed copies of a statement from the vendor, certifying that each container of seed delivered is at least equal to the specification requirements and is fully labeled in accordance with section 2.1 above, shall be submitted to the engineer. Where seed is furnished with an appreciably higher total percentage of pure live seed than the minimum required in the special provisions, the statement from the vendor will include a certification as to the amounts of pure live seed of each species furnished. The above statement shall appear on or with all copies of invoices for the seed. Each lot of seed shall be subject to sampling and testing at the discretion of the engineer. Sampling and testing will be in accordance with the latest "Rules and Regulations Under the Federal Seed Act" in effect on the date of the purchase order. Where seed is not delivered in sufficient time to permit sampling and testing, the sowing operations shall not be delayed pending reports of these tests.

In the event that reports of seed analysis were not received prior to sowing, and the tests made thereafter indicate the seed used did not meet the specification requirements, the engineer may require the contractor to reseed the entire area affected during the next suitable season with sufficient seed to provide the total quantity of pure live seed specified, or will deduct from the contract payment an amount sufficient to cover the cost of seed and reseedling operations.

(b) *Lime and Fertilizer.* The engineer shall be furnished with duplicate copies of invoices of all lime and fertilizer used on the project. Invoices for lime will show total minimum carbonates and minimum percentages of the material furnished that pass the No. 20 mesh and No. 100 mesh sieves. Invoices for fertilizer will show the kind and analysis furnished. Each lot of lime and fertilizer shall be subject to sampling and testing at the discretion of the engineer, using approved methods in determining compliance with applicable State laws.

In the event that these tests cannot be completed prior to the application of lime and fertilizer, and the tests when made show that lime and fertilizer used were below the specification requirements, the contractor may be required, at the discretion of the engineer, to supply and distribute sufficient additional materials over the entire area affected to bring the amounts up to specification requirements, or have deducted from the contract payments an amount sufficient to cover the cost of such quantities of lime and fertilizer and the application thereof.

CONSTRUCTION METHODS

901-3.1 GENERAL. (a) Areas to be seeded, those requiring special preparation of the ground surface such as tilling, and those in a satisfactory condition to remain undisturbed, will be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface and for handling and placing all required materials shall be on hand, in good operating condition, and shall be approved by the engineer before the various operations are started. The contractor shall demonstrate to the engineer before starting the various operations that the application of required materials will be made at the specified rates.

During the operations of distributing lime or fertilizer, or sowing seed, the areas covered shall be checked against the quantities of material used when one-fourth, one-half, and three-fourths of the affected areas have been covered to verify the proper rate of application. Upon completion of the distributing operations, a final check of the total quantities of materials used shall be made against the total acreage limed, fertilized, and sown. If it is determined, by this checking of quantities used or by inspection either immediately after distributing the materials or after there is a show of green, that uniform distribution at rates at least equal to the minimum required has not been made, the contractor may be required, at the discretion of the engineer, either to distribute additional quantities of these materials on the areas designated to meet the specification requirements, providing seasonal conditions are favorable, or have deducted from his payment an amount sufficient to cover the cost of the material and also the cost of distribution. Skipped areas wider than the distance between drills, in the case of drilling operations, or areas averaging more than four (4) inches in width in the case of broadcasting operations, are subject also to this provision.

When conditions are such, by reason of extreme drought, excessive moisture, or other factors, that satisfactory results are not likely to be obtained, the work shall be stopped and it shall be resumed only when the desired results are likely to be obtained.

(b) *Order of Work.* The order of work operations shall be as follows, except as modified in the special provisions:

- (1) Removing debris.
- (2) Applying lime.
- (3) Tilling.
- (4) Smooth grading.
- (5) Applying fertilizer.
- (6) Incorporating fertilizer.
- (7) Finished grading.
- (8) Sowing seed.
- (9) Cleaning up.
- (10) Compacting.

901-3.2 PREPARING THE GROUND SURFACE. (a) *Removing of Debris.* Prior to the commencement of tilling and smooth grading, all large stones, cables, wire, or any waste materials shall be removed from the site. All heavy growths of vegetation on the site which may interfere seriously with subsequent smooth grading, tilling, or sowing operations shall be mowed, raked, and burned, used for mulch if suitable, or hauled off the site, as directed by the engineer. Ash deposits accumulated from burning materials on the site shall be distributed thinly over the surrounding area as directed by the engineer.

During tilling operations the ground surface shall be kept cleared of all large stones, roots, cable, wire, or any other materials which might hinder subsequent fertilizing, sowing, or maintenance operations.

(b) *Tilling.* The areas to be seeded shall be thoroughly prepared to the depth stated in the special provisions by disking, harrowing, cultipacking, or by other means approved by the engineer. Limited areas as shown on the plans which are too compact to respond to these operations shall receive special scarification previous to final tilling operations. Tilling shall continue until the condition of the soil is acceptable to the engineer as suitable for the type of seeding to be used.

(c) *Smooth Grading.* Where final grades have been established by others on the areas to be seeded, they shall be shown on the plans. Where grades have not been established, the areas shall be smooth-graded and the surfaces left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

(d) *Finished Grading.* Upon completion of tilling, liming, and fertilizing operations, and immediately prior to sowing seed, the areas shall be given a finished grading as needed to correct irregularities in the surface, due to the above operations or other causes, and to restore the prescribed grades.

901-3.3 LIMING AND FERTILIZING. (a) *Applying Lime.* Lime shall be distributed uniformly over the areas to be seeded at a rate which will provide not less than the minimum quantity stated in the special provisions. Distribution shall be by hand or by an approved distributor or other equipment satisfactory to the engineer.

(b) *Applying Fertilizer.* Fertilizer shall be distributed uniformly over the areas to be seeded at a rate which will provide not less than the minimum quantity of each fertilizer ingredient as stated in the special provisions. Distribution shall be by hand or by a common fertilizer distributor, or other equipment approved by the engineer. Use of a grain or seed drill, equipped to sow seed and distribute fertilizer at the same time, will be permitted.

(c) *Incorporating Lime.* Following distribution, lime shall be incorporated into the soil to the full depth of tilling by disking, harrowing, or other methods acceptable to the engineer. Lime may be incorporated during the tilling operations except in the case of plowing or when otherwise stated in the special provisions.

(d) *Incorporating Fertilizer.* Following distribution, fertilizer shall be incorporated into the soil to the depth stated in the special provision. If the depth of tilling and the depth of incorporating fertilizer are the same, the incorporating may be done as a part of the tilling operation, except that inorganic fertilizer containing nitrogen shall not be applied and incorporated more than 48 hours prior to sowing the seed, or when otherwise stated in the special provisions. When the depth of tilling is greater than the depth of incorporating fertilizer, the incorporating may be included as part of the disking or harrowing operations, providing it is done just prior to sowing seed.

901-3.4 SOWING SEED. (a) *General.* All sowing of seed shall be completed between the dates stated in the special provisions. Sowing delayed beyond the specified dates, and due to circumstances beyond the contractor's control, may be continued upon written approval from the engineer, but in no instance more than ten (10) calendar days beyond the latest date stated in the special provisions. The contractor shall employ a method of sowing satisfactory to the engineer, and where practical he shall make use of approved power-drawn drills or seeders, hand seeders, or other approved equipment. When sowing seed mixtures, the contractor shall keep the seed thoroughly mixed during the sowing operations to prevent separation of species and the subsequent lack of uniform distribution of species. When drills or other sowing equipment are used, they shall be equipped with markers or other means to provide that the successive seeded strips will overlap or be separated by a space no greater than the space between drills of the equipment being used. The sowing shall be stopped when satisfactory results are not likely to be obtained due to excessive moisture conditions, high winds, or other unfavorable conditions. It shall be resumed only when conditions are favorable again or when alternate or corrective measures and procedures which are approved by the engineer have been adopted. The rates of sowing stated in special provisions are on the basis of the minimum total of pure live seed per acre. Actual sowing rates will be in excess of this quantity because of the existence of inert materials in all lots of seed. The actual seeding rate of the seed as delivered (including the inert and other material) is determined by dividing the minimum pounds of pure live seed, as stated in the special provisions, by the percentage by weight of pure live seed of the delivered seed.

(b) *Broadcast Sowing.* Seed shall be broadcast either by hand or by approved sowing equipment at a rate which will provide not less than the minimum quantity of pure live seed stated in the special provisions. The seed shall be uniformly distributed over the designated areas. If sowing is by hand methods, one-half the seed shall be sown when the sower is moving in one direction, and the remainder sown with the sower moving at right angles to the first direction. Where seed is sown by means of approved broadcasting equipment, the seed may be sown with a single pass of the equipment. Broadcast sowing shall not be done during windy weather. The seed shall be

covered by means of a brush harrow, spike-tooth harrow, chain harrow, cultipacker, or other approved device, so that most of the seed will be placed within the depth range stated in the special provisions.

(c) *Drill Sowing.* Drill sowing shall be done with approved equipment which will provide the row spacing, as stated in the special provisions, and uniform distribution of seed over the designated areas. The use of two or more drills in tandem to accomplish this spacing is permissible. The seed shall be drilled so that most of the seed will be placed within the depth range stated in the special provisions. Seed shall be evenly drilled at a rate which will provide not less than the minimum quantity of pure live seed as stated in the special provisions.

(d) *Cleaning Up.* After the seed has been sown, and prior to compacting, the surface shall be cleared of all stones, or other objects larger than two (2) inches in greatest diameter, and all wire, roots, brush, or other objects that may interfere with subsequent mowing operations.

(e) *Compacting.* Immediately after the broadcast or drill sowing operations have been completed, unless otherwise directed by the engineer, the entire area shall be compacted by means of a cultipacker, roller, or other approved equipment, in order to reduce air pockets to a minimum. When a cultipacker or other equipment that leaves a roughened surface is used, the final rolling shall be along the contour and at right angles to the existing slopes to reduce water erosion, or at right angles to the prevailing wind to reduce dust, as directed by the engineer.

901-3.5 ESTABLISHING TURF. (a) *General.* The contractor shall be responsible for the proper care of seeded areas during the period when the grass is becoming established. This period shall begin immediately after sowing and shall continue for the period stated in the special provisions, unless the desired cover is established in a shorter period of time.

(b) *Protection.* The contractor shall protect the area against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricades that may be shown on the plans before or immediately after sowing is completed.

(c) *Mowing.* The seeded areas shall be mowed with approved mowing equipment at approximately the dates stated in the special provisions. The dates of mowing and total area to be mowed may be modified by the engineer or by the contractor with the approval of the engineer, depending upon climatic and growth conditions and the needs for mowing of specific areas. In the event that a temporary cover crop and weeds or other undesirable vegetation are permitted to grow to such an extent that, either cut or uncut, they threaten to smother the permanent species, they shall be mowed and the clippings raked and removed from the area.

(d) *Refertilizing.* Areas needing refertilizing shall be designated by the engineer at least fifteen (15) days prior to the time application is required. The fertilizer shall be distributed by common broadcast

fertilizer spreader during a period when the grass is dry. The fertilizer shall be the kind or grade as stated in the special provision under paragraph 2.3.

Fertilizer shall be distributed uniformly over the areas designated by the engineer to be refertilized at a rate which will provide not less than the minimum quantities of the fertilizer ingredient as stated in the special provisions. Where more than one fertilizer ingredient is required, they shall be applied as separate operations at a time interval not less than that time stated in the special provisions. If serious "burning" of the turf develops from the first application, or when climatic conditions indicate a definite threat of "burning," the following applications will be delayed beyond the intervals stated in the special provisions in order to avoid excessive damage.

(e) *Reseeding.* Areas needing reseeded will be designated by the engineer at least fifteen (15) days prior to the date when this operation shall be started. Reseeding shall be with the original seed formula, and with the method of sowing and at a rate which will provide not less than the minimum amount of pure live seed stated in the special provisions. The reseeded operation shall be done in a manner that will cause a minimum of disturbance to the existing stand of grass.

901-3.6 REPAIRING. When the surface has become gullied or otherwise damaged, during the period covered by this contract, the affected areas shall be repaired to re-establish the grade and the condition of the soil, as directed by the engineer and provided for in this specification, and shall then be reseeded as specified in section 3.4 above. Layer placing and compacting of fill material will be in accordance with the applicable grading specifications.

METHOD OF MEASUREMENT

901-4.1 The area of ground surface preparation to be paid for shall be the number of acres and tenths thereof, measured by surface area, prepared, and accepted.

901-4.2 The area of liming to be paid for shall be the number of acres and tenths thereof, measured by surface area, limed, and accepted.

901-4.3 The area of fertilizing to be paid for shall be the number of acres and tenths thereof, measured by surface area, fertilized, and accepted.

901-4.4 The area of sowing to be paid for shall be the number of acres and tenths thereof, measured by surface area, sown, and accepted.

901-4.5 The area of mowing to be paid for shall be the number of acres for each separate mowing operation, measured by surface area, mowed, and accepted.

901-4.6 The area of refertilizing to be paid for shall be the number of acres for each separate refertilizing operation, measured by surface area, refertilized, and accepted.

901-4.7 The area of reseeding to be paid for shall be the number of acres and tenths thereof, measured by surface area, reseeded, and accepted.

901-4.8 The quantity of soil for repair work to be paid for shall be the number of cubic yards of soil measured in the vehicle at the point of delivery, completed in place, and accepted.

BASIS OF PAYMENT

901-5.1 The acreage of ground surface preparation, determined as provided above, shall be paid for at the contract unit price per acre for "Preparing the Ground Surface," which price and payment shall constitute full compensation for removing debris, tilling, smooth and finished grading, incorporating lime and fertilizer, cleaning up, protection, and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.2 The acreage of liming, determined as provided above, shall be paid for at the contract unit price per acre for "Liming," which price and payment shall constitute full compensation for furnishing and applying lime and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.3 The acreage of fertilizing, determined as provided above, shall be paid for at the contract unit price per acre for "Fertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer, and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.4 The acreage of sowing seed, determined as provided above, shall be paid for at the contract unit price per acre for "Sowing Seed," which price and payment shall constitute full compensation for furnishing and sowing seed and compacting, and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.5 The acreage of mowing, determined as provided above, shall be paid for at the contract unit price per acre for each "Mowing," which price and payment shall constitute full compensation for all mowing, and for any required raking and removal of excessive growth from the area, and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.6 The acreage for refertilizing, determined as provided above, shall be paid for at the contract unit price per acre for "Refertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.7 The acreage for reseeding, determined as provided above, shall be paid for at the contract unit price per acre for "Reseeding," which price and payment shall constitute full compensation for furnishing and sowing seed, and for all labor, equipment, tools, and incidentals necessary to complete the work.

901-5.3 The yardage of soil, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Repairing," which price and payment shall constitute full compensation for furnishing, hauling, placing, spreading, and compacting soil, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- Item T-901-5.1 Preparing the Ground Surface—per acre.
- Item T-901-5.2 Liming—per acre.
- Item T-901-5.3 Fertilizing—per acre.
- Item T-901-5.4 Sowing Seed—per acre.
- Item T-901-5.5 Mowing—per acre.
- Item T-901-5.6 Refertilizing—per acre.
- Item T-901-5.7 Reseeding—per acre.
- Item T-901-5.8 Repairing—per cubic yard.

ITEM T-902 SEEDING (Modified)

DESCRIPTION

902-1.1 This item shall consist of preparing the ground surface, furnishing and sowing seed, compacting and repairing, in accordance with this specification at the locations shown on the plans, or as directed by the engineer.

MATERIALS

902-2.1 SEED. The seed or seed mixture to be furnished, and the minimum percentage by weight of pure live seed of each species in each lot of seed, and the maximum percentage of weed seed, shall be as stated in the special provisions. When the total percentage of pure live seed furnished is higher than the minimum required, the ratio of seed of the named species shall be approximately the same as that stated in the special provisions. All seed used shall be labeled in accordance with U. S. Department of Agriculture "Rules and Regulations Under the Federal Seed Act" in effect on the date of invitation for bids. All seed shall be furnished in standard containers, unless exception is granted by the engineer. Seed which has become wet, moldy, or otherwise damaged in transit or storage, will not be acceptable.

902-2.2 SOIL FOR REPAIRS. The soil for fill, and topsoiling of areas to be repaired, shall be at least of equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent compacting, seeding, or establishing, and shall be approved by the engineer before being placed.

902-2.3 INSPECTION AND TESTS. Duplicate signed copies of a statement from the vendor certifying that each container of seed delivered is at least equal to the specification requirements, and is fully labeled in accordance with section 2.1 above, shall be submitted to the engineer. Where seed is furnished with an appreciably higher total percentage of pure live seed than the minimum required in the special provisions, the statement from the vendor will include a certification as to the amounts of pure live seed of each species furnished. The above statement shall appear on or with all copies of invoices for the seed. Each lot of seed shall be subject to sampling and testing, at the discretion of the engineer. Sampling and testing will be in accordance with the latest "Rules and Regulations Under the Federal Seed Act" in effect on the date of the purchase order. Where seed is not

delivered in sufficient time to permit sampling and testing, the sowing operations shall not be delayed pending reports of these tests.

In the event that reports of seed analysis were not received prior to sowing and the tests made thereafter indicate the seed used did not meet the specification requirements, the engineer may require the contractor to reseed the area during a proper season with sufficient seed to provide the total quantity of pure live seed specified, or will deduct from the contract payment an amount sufficient to cover the cost of seed and reseeding operations.

CONSTRUCTION METHODS

902-3.1 GENERAL. Areas to be seeded, those requiring special preparation of the ground surface such as tilling, and those in a satisfactory condition to remain undisturbed, will be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface and for sowing of seed uniformly at the required rate shall be on hand, in good operating condition, and shall be approved by the engineer before operations are started.

While sowing seed, the areas sown shall be checked against the quantity of seed used when one-fourth, one-half, and three-fourths of the affected areas have been sown to verify the proper rate of sowing. Upon completion of the sowing, a final check of the total quantities of seed used shall be made against the total acreage sown. If it is determined, by this checking of quantities used or by inspection either immediately after sowing or after there is a show of green, that sowing has not been uniform or at rates at least equal to the minimum required, the contractor may be required, at the discretion of the engineer, either to sow additional seed on the areas designated to meet the specification requirements, providing seasonal conditions are favorable, or have deducted from his payment an amount sufficient to cover the cost of the seed and also the cost of sowing. Skipped areas wider than the distance between drills in the case of drilling operations, or areas averaging more than four (4) inches in width in the case of broad-casting operations, are also subject to this provision.

When conditions are such, by reason of extreme drought, excessive moisture or other factors, that satisfactory results are not likely to be obtained, the work shall be stopped and it shall be resumed only when the desired results are likely to be obtained.

902-3.2 PREPARING THE GROUND SURFACE. (a) *Removing Debris.* Prior to the commencement of tilling and smooth grading, all large stones, cables, wire, or any waste materials shall be removed from the site. All heavy growths of vegetation on the site which may interfere seriously with subsequent tilling, smooth or finished grading, or sowing operations shall be cut, raked and burned, used for mulch if suitable, or hauled off the site, as directed by the engineer. Ash deposits accumulated from burning materials on the

site shall be distributed thinly over the surrounding area, as directed by the engineer.

During tilling operations the ground surface shall be kept cleared of all large stones, roots, cable, wire, or any other materials which might hinder subsequent sowing or maintenance operations.

(b) *Tilling.* The areas to be seeded shall be thoroughly prepared to the depth stated in the special provisions by disking, harrowing, cultipacking, or by other means approved by the engineer. Limited areas as shown on the plans which are too compact to respond to these operations shall receive special scarification previous to final tilling operations. Tilling shall continue until the condition of the soil is acceptable to the engineer as suitable for the type of seeding to be used.

(c) *Smooth Grading.* Where final grades have been established by others on the areas to be seeded, they shall be shown on the plans. Where grades have not been established, the areas shall be smooth-graded and the surfaces left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

(d) *Finished Grading.* Upon completion of tilling operations, and immediately prior to sowing seed, the areas shall be given a finished grading as needed to correct irregularities in the surface, due to the above operations or other causes, and to restore the prescribed grades.

902-3.3 SOWING SEED. (a) *General.* All sowing of seed shall be completed between the dates stated in the special provisions. Sowing delayed beyond the specified dates, and due to circumstances beyond the contractor's control, may be continued upon written approval from the engineer, but in no instance can the time for sowing permanent species be extended more than (10) calendar days beyond the latest date stated in the special provisions. The contractor shall employ a method of sowing satisfactory to the engineer, and where practical he shall make use of approved power-drawn drills or seeders, hand seeders, or other approved equipment. When sowing seed mixtures, the contractor shall keep the seed thoroughly mixed during the sowing operations to prevent separation of species and the subsequent lack of uniform distribution of species. When drills or other sowing equipment are used, they shall be equipped with markers or other devices to provide that the successive seeded strips will overlap or be separated by a space no greater than the space between drills of the equipment being used. Sowing shall be stopped when satisfactory results are not likely to be obtained due to excessive moisture conditions, high winds, or other unfavorable conditions. It shall be resumed only when conditions are favorable again or when alternate or corrective measures and procedures which are approved by the engineer have been adopted.

The rates of sowing stated in special provisions are on the basis of the minimum total pure live seed per acre. Actual sowing rates will be in excess of this quantity because of the existence of inert materials in all lots of seed. The actual seeding rate of the seed as delivered

(including the inert and other material) is determined by dividing the minimum pounds of pure live seed as stated in the special provisions by the percentage by weight of pure live seed of the delivered seed.

(b) *Broadcast Sowing.* Seed shall be broadcast either by hand or by approved sowing equipment at a rate which will provide not less than the minimum quantity of pure live seed stated in the special provisions. The seed shall be uniformly distributed over the designated areas. If sowing is by hand methods, one-half of the seed shall be sown when the sower is moving in one direction, and the remainder sown with the sower moving at right angles to the first direction. Where seed is sown by means of approved broadcasting equipment, the seed may be sown with a single pass of the equipment. Broadcast seeding shall not be done during windy weather. The seed shall be covered by means of a brush harrow, spike-tooth harrow, chain harrow, cultipacker, or other approved device, so that most of the seed will be placed within the depth range stated in the special provisions.

(c) *Drill Sowing.* Drill sowing shall be done with approved equipment which will provide the row spacing, as stated in the special provisions, and uniform distribution of seed over the designated areas. The use of two or more drills in tandem to accomplish this spacing is permissible. The seed shall be drilled so that most of the seed will be placed within the depth range stated in the special provisions. Seed shall be evenly drilled at a rate which will provide not less than the minimum quantity of pure live seed, as stated in the special provisions.

(d) *Cleaning up.* After the seed has been sown, and prior to compacting, the surface shall be cleared of all stones, or other objects larger than two (2) inches in greatest diameter, and all wire, roots, brush, or other objects that may interfere with subsequent mowing operations.

(e) *Compacting.* Immediately after the broadcast or drill-sowing and cleaning up operations have been completed, unless otherwise directed by the engineer, the entire area shall be compacted by means of a cultipacker, roller, or other approved equipment, in order to reduce air pockets to a minimum. When a cultipacker or other equipment that leaves a roughened surface is used, the final rolling shall be along the contour and at right angles to the existing slopes to reduce water erosion, or at right angles to the prevailing wind to reduce dust, as directed by the engineer.

902-3.4 PROTECTION. The contractor shall protect the area against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricade that may be shown on the plans before or immediately after seeding is completed.

902-3.5 REPAIRING. When the surface has become gullied or otherwise damaged during the period covered in this contract, the affected areas shall be repaired to re-establish the grade and the condition of the soil, as directed by the engineer and provided for in this specification, and shall then be reseeded as specified in section 3.3

above. Layer placing and compacting of fill material will be in accordance with the applicable grading specifications.

METHOD OF MEASUREMENT

902-4.1 The area of ground surface preparation to be paid for shall be the number of acres and tenths thereof, measured by surface area, prepared, and accepted.

902-4.2 The area of sowing to be paid for shall be the number of acres and tenths thereof, measured by surface area, sown, and accepted.

902-4.3 The quantity of soil for repair work to be paid for shall be the number of cubic yards of soil, measured in the vehicle at the point of delivery, completed in place, and accepted.

BASIS OF PAYMENT

902-5.1 The acreage of ground surface preparation, determined as provided above, shall be paid for at the contract unit price per acre for "Preparing the Ground Surface," which price and payment shall constitute full compensation for removing debris, tilling, smooth and finished grading, cleaning up, protection, and for all labor, equipment, tools, and incidentals necessary to complete the work.

902-5.2 The acreage of sowing seed, determined as provided above, shall be paid for at the contract unit price per acre for "Sowing Seed," which price and payment shall constitute full compensation for furnishing and sowing seed and compacting, and for all labor, equipment, tools, and incidentals necessary to complete the work.

902-5.4 The yardage of soil, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Repairing," which price and payment shall constitute full compensation for furnishing, hauling, placing, spreading, and compacting soil, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item T-902-5.1 Preparing the Ground Surface—per acre.

Item T-902-5.2 Sowing Seed—per acre.

Item T-902-5.3 Repairing—per cubic yard.

ITEM T-903 SPRIGGING

DESCRIPTION

903-1.1 This item shall consist of preparing the ground surface, furnishing and applying lime and fertilizer, obtaining sprigs from designated areas on the site or furnishing sprigs from approved sources off the site, planting sprigs, compacting, watering, establishing, and repairing in accordance with this specification at the locations shown on the plans or as directed by the engineer.

MATERIALS

903-2.1 SPRIGS. Sprigs, when furnished by the contractor, shall be the healthy living stems (stolons or rhizomes), of the grass species stated in the special provisions, and attached roots with little adhering soil, obtained from approved sources where the sod is heavy and thickly matted. The presence of weeds or other material which might be detrimental to the proposed planting will be cause for rejection of sprigs.

903-2.2 LIME. Lime shall be ground limestone containing not less than eighty-five (85) percent of total carbonates, and shall be ground to such fineness that ninety (90) percent will pass through a No. 20 mesh sieve and fifty (50) percent will pass through a No. 100 mesh sieve. Coarser material will be acceptable, providing the rates of application are increased to provide not less than the minimum quantities stated in the special provisions on the basis of the two sieve requirements above.

903-2.3 FERTILIZER. Fertilizers shall be commercial carriers of available plant food elements or combinations thereof, either as inorganic or organic materials, as stated in the special provisions, and shall conform to the applicable State fertilizer laws. The fertilizer shall be uniform in composition, dry, and free-flowing material in condition for application by suitable equipment. The fertilizer shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable.

903-2.4 WATER. The water shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass. It shall be subject to the approval of the engineer prior to use.

903-2.5 SOIL FOR REPAIRS. The soil for fill, and topsoiling of areas to be repaired, shall be at least of equal quality to that

which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other materials that will interfere with subsequent planting, compacting, or establishing, and shall be approved by the engineer before being placed.

903-2.6 INSPECTION AND TESTS. (a) *Sprigs.* Within five (5) days following acceptance of the bid, the engineer shall be notified of the sources of sprigs to be furnished by the contractor. The sprigs will be subject to inspection during the planting period, and any material which has been permitted to dry out excessively, or which is not viable, will be rejected.

If it is determined upon final inspection that inferior, damaged, or otherwise unacceptable plant material has been used in the planting operation, the engineer may require the contractor to replant the affected areas to meet specification requirements, or have deducted from the contract payment an amount sufficient to cover the cost of additional plant material and the planting thereof.

(b) *Lime and Fertilizer.* The engineer shall be furnished with duplicate copies of invoices of all lime and fertilizer used on the project. Invoices for lime will show minimum carbonates and minimum percentages of the material furnished that pass the No. 20 mesh and No. 100 mesh sieves. Invoices for fertilizer will show the kind and analysis furnished. Each lot of lime and fertilizer shall be subject to sampling and testing at the discretion of the engineer, using approved methods in determining compliance with applicable State laws.

In the event that these tests cannot be completed prior to the application of lime and fertilizer, and the tests when made show that lime and fertilizer used were below the specification requirements, the contractor may be required, at the discretion of the engineer, to supply and distribute sufficient additional materials over the entire area affected to bring the amounts up to specification requirements, or have deducted from the contract payment an amount sufficient to cover the cost of such quantities of lime and fertilizer and the application thereof.

CONSTRUCTION METHODS

903-3.1 GENERAL. (a) Areas to be sprigged and the location of sprigging material, if available on the site, will be shown on the plans. Areas requiring special ground surface preparation such as tilling, and those in a satisfactory condition to remain undisturbed, will also be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface and for handling and placing all required materials shall be on hand, in good condition, and shall be approved by the engineer before the various operations are started. The contractor shall demonstrate to the engineer, before starting the various operations, that the planting and application of required materials will be made at the specified rates.

When conditions are such, by reason of extreme drought, excessive moisture or other factors, that satisfactory results are not likely to be

obtained, the work shall be stopped and it shall be resumed only when the desired results are likely to be obtained.

During the operations of distributing lime or fertilizer, or broadcast planting of sprigs, the areas covered shall be checked against the quantity of materials used when one-fourth, one-half, and three-fourths of the affected areas have been covered to verify the proper rate of application. Upon completion of the distributing operations, a final check of the total quantities of materials used shall be made against the total acreage limed, fertilized, and planted. If it is determined, by this checking of quantities used or by inspection either immediately after distributing the materials or after there is a show of green, that uniform distribution, at rates at least equal to the minimum required has not been made, the contractor may be required, at the discretion of the engineer, either to distribute additional quantities of these materials on the areas designated to meet the specification requirements, providing seasonal conditions are favorable, or have deducted from his payment an amount sufficient to cover the cost of the material and also the cost of distribution.

(b) *Order of Work.* The order of work operations shall be as follows unless modified by special provisions:

- (1) Removing debris.
- (2) Applying lime.
- (3) Tilling.
- (4) Smooth grading.
- (5) Applying fertilizer.
- (6) Incorporating fertilizer.
- (7) Harvesting sprigs.
- (8) Planting sprigs.
- (9) Cleaning up.
- (10) Compacting.
- (11) Finished grading.
- (12) Watering.

903-3.2 PREPARING THE GROUND SURFACE. (a) *Removing Debris.* Prior to the commencement of tilling and smooth grading, all large stones, cables, wire, or any other materials shall be removed from the site. All heavy growths of vegetation on the site, as indicated on the plans, shall be mowed, raked and burned, used for mulch if suitable, or hauled off the site, as directed by the engineer. Ash deposits accumulated from burning materials on the site shall be distributed thinly over the surrounding area as directed by the engineer.

During tilling operations, the ground surface shall be kept cleared of all large stones, roots, cable, wire, or any other materials which might hinder planting, finished grading, or subsequent maintenance operations.

(b) *Tilling.* The areas to be sprigged shall be thoroughly loosened to the depth stated in the special provisions by disking, scarifying, or by other means approved by the engineer. Limited areas as shown on the plans which are too compact to respond to these operations shall

receive scarification prior to final tilling operations. Tilling shall continue until practically all the large clods are broken up and the condition of the soil is acceptable to the engineer as being suitable for planting sprigs.

(c) *Smooth Grading.* Where final grades have been established by others, they shall be shown on the plans. Where grades have not been established, the areas shall be graded as required by plans and specifications and the surfaces shall be left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

(d) *Finished Grading.* As soon as the soil is in a workable condition after compacting, the planted area shall be finished graded as needed to correct irregularities in the surface, due to previous operations or other causes, and to restore previously established grades. Steep slopes or other operations as shown on the plans may be excepted from this operation. Finished grading may be accomplished in part by attaching a heavy drag to the roller, but additional smoothing operations shall be performed at an angle of approximately 45 degrees to the direction at which the roller was operated. In no case shall finished grading be delayed until grass has emerged.

903-3.3 LIMING AND FERTILIZING. (a) *Applying Lime.* Lime shall be distributed uniformly over the areas to be sprigged at a rate which will provide not less than the minimum quantity stated in the special provisions. Distribution shall be by hand or by an approved type of distributor or other equipment satisfactory to the engineer.

(b) *Applying Fertilizer.* Fertilizer shall be distributed uniformly over the area to be sprigged at a rate which will provide not less than the minimum quantity of each fertilizer ingredient, as stated in the special provisions. Distribution shall be by hand or by a common fertilizer distributor, grain drill, planting machine, or other approved equipment.

(c) *Incorporating Lime.* Following distribution, lime shall be incorporated into the soil to the full depth of tilling by disking, harrowing, or other methods acceptable to the engineer. Lime may be incorporated during the tilling operations, except in the case of plowing or when otherwise stated in the special provisions.

(d) *Incorporating Fertilizer.* Following distribution, fertilizer shall be incorporated into the soil to the depth stated in the special provision. If the depth of tilling and the depth of incorporating fertilizer are the same, the incorporating may be done as a part of the tilling operation, except that inorganic fertilizer containing nitrogen shall not be applied and incorporated more than 48 hours prior to planting sprigs, or when otherwise stated in the special provisions. When the depth of tilling is greater than the depth of incorporating fertilizer, the incorporating may be included as part of the disking or harrowing operations, providing it is done just prior to planting sprigs.

903-3.4 HARVESTING SPRIGS. The sprigs obtained from sources off the site shall be from suitable areas as close as practical to the planting site. Regardless of the source, sprigging material which contains grass and weeds taller than six (6) inches shall be mowed to a height of three (3) inches, and the clippings raked and removed before harvesting begins. Harvesting may be performed by any method acceptable to the engineer, including criss-cross cultivation, shallow plowing, or listing to thoroughly loosen the sprigs from the soil and to bring them to the surface. Sprigs shall be collected or bunched for loading within thirty (30) minutes after loosening, by raking with a side delivery rake, hay rake, by hand or other acceptable means.

Sprigs shall be placed in small piles and kept moist until they are planted. Sprigs which have over-heated will be rejected. Not more than twenty (20) hours shall elapse between initial harvesting operations and planting sprigs, except that, when adverse weather or other uncontrollable conditions interrupt the operations, an extension of time may be granted by the engineer, provided the sprigs are still viable and in good condition.

903-3.5 PREPARING SPRIGS FOR PLANTING. In the event that the sprigs obtained are too long to satisfactorily feed through the delivery mechanism of the sprigging machine, the sprigs shall first be run through an ensilage cutter or a similar machine set to cut at least seventy (70) percent of the sprigs to a minimum length of four (4) inches. When planting by hand or machines that do not require short sprigs, this preparation can be omitted. Sprigs shall be thoroughly moistened immediately following cutting.

903-3.6 PLANTING SPRIGS. (a) *General.* Sprigging shall be done only when satisfactory results can be expected. The sprigging work shall be stopped when the soil moisture content falls below that stated in the special provisions, when the soil becomes puddled due to operation of equipment, during periods of high winds, or when the temperature is below 32° F. It shall be resumed only when the conditions are favorable again or when alternate or corrective measures and procedures are adopted and approved by the engineer.

(b) *Broadcast Sprigging.* Sprigs shall be broadcast by hand or by a manure spreader or other suitable device in a uniform layer over the prepared surface at a rate which will provide not less than the minimum quantity stated in the special provisions. Determination of an acceptable volume of sprigs shall be based on measurements at that density assumed naturally by sprigs in a pile thirty-six (36) inches high. The sprigs then shall be forced into the soil to the approximate depth stated in the special provisions by means of a straight spade or similar hand tool, or with a disk harrow, or other approved equipment, set to cover the sprigs to the required depth.

(c) *Row Sprigging.* Furrows spaced at intervals not greater than that stated in the special provisions shall first be opened to the depth necessary to insure covering of sprigs, after compaction, to the approxi-

mate depth stated in the special provisions. Rows shall be opened at right angles to the existing slopes to prevent water erosion, or at right angles to the prevailing wind to prevent dust, as directed by the engineer. As soon as practicable after the opening of furrows, the sprigs shall be placed by hand or by planting machine in continuous rows with the ends overlapping. When a planting machine is used, it shall meet the minimum requirements stated in the special provisions. The sprigs shall be covered immediately by filling in the furrows in such manner that the surface is left even at the established grade. The time interval between opening the furrows and final compaction shall not exceed that stated in the special provisions.

(d) *Spot Sprigging.* Spot sprigging shall be performed as specified in (c) above, except that, instead of planting in continuous rows, a group of sprigs shall be planted at the intervals not greater than that stated in the special provisions, and each group shall contain at least four viable sprigs or twenty-five (25) linear inches of sprigs.

903-3.7 CLEANING UP. After the planting of sprigs has been completed and prior to compacting, the surface shall be cleared of all stones, or other objects larger than two (2) inches in greatest diameter, and of all wire, roots, brush, or other objects that may interfere with subsequent mowing or maintenance operations.

903-3.8 COMPACTING. Immediately after the planting of sprigs and cleaning up have been completed, the entire sprigged area shall be compacted by means of a smooth or corrugated roller with the per linear inch weight stated in the special provisions, or a pneumatic roller that will exert equal pressure. The smooth or corrugated roller shall be equipped with a cleaner, and if the soil type is such that these rollers cannot be operated without picking up excessive soil and thereby uncovering sprigs a pneumatic roller will be required.

903-3.9 WATERING. Watering will be required if sprigging is authorized when the soil moisture content is below the minimum as stated in the special provisions. Water shall be delivered through pipe and hose or in containers which will assure delivery of a full measured quantity without waste. When water is required to be applied in furrows it shall be distributed uniformly along the bottoms of the furrows immediately before they are covered and at the rate stated in the special provisions. When water is required to be applied on the surface it shall be uniformly distributed over the area designated to be watered by means of hose sprinklers, sprinkler trucks, or other equipment approved by the engineer and at the rate stated in the special provisions. Sprinkling shall be done slowly enough to assure maximum penetration into the soil, but it shall be done rapidly enough so that the required quantity for a single application shall be delivered within a time interval not greater than that stated in the special provisions. When directed by the engineer, additional watering by the surface application method shall be done as provided above and at the rate and within the time interval stated in the special provisions. In all cases watering shall be done in a manner which will avoid erosion due

to the application of excessive quantities and which will avoid damage to the finished surface by wheel scars.

903-3.10 ESTABLISHING TURF. (a) *General.* The contractor shall be responsible for the proper care of the sprigged areas during the period when the plants are becoming established. This period shall begin immediately after planting and continue for the period stated in the special provisions.

(b) *Protection.* The contractor shall protect the area against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricades that may be shown on the plans before or immediately after planting is completed.

(c) *Mowing.* The sprigged areas shall be mowed with approved mowing equipment on approximately the dates stated in the special provisions. The dates of mowing and total area to be mowed may be modified by the engineer or by the contractor with the approval of the engineer, depending upon climatic and growth conditions and the needs for mowing of specific areas. In the event that a temporary cover crop and weeds or other undesirable vegetation grow to such an extent that either cut or uncut they threaten to smother the sprigged species, they shall be mowed and the clippings raked and removed from the area.

(d) *Refertilizing.* Areas needing fertilizing shall be designated by the engineer at least fifteen (15) days prior to the time application is required. The fertilizer shall be distributed by common broadcast fertilizer spreader during a period when the plants are dry, and in a manner approved by the engineer which will cause a minimum of disturbance to the plants. The fertilizer shall be the kind or grade as stated in the special provisions under paragraph 2.3.

Fertilizer shall be distributed uniformly over the areas designated by the engineer to be refertilized at a rate which will provide not less than the minimum amounts of the fertilizer ingredient as stated in the special provisions. Where more than one fertilizer ingredient is required they shall be applied as separate operations at a time interval not less than that stated in the special provisions. If serious "burning" of the turf develops from the first application, or when climatic conditions indicate that there is a definite threat of "burning," the following applications will be delayed beyond the interval stated in the special provisions in order to avoid excessive damage.

(e) *Resprigging.* Areas needing resprigging shall be designated by the engineer at least fifteen (15) days prior to the period stated for such work to commence. Material for resprigging shall be similar to that required for the original planting. The method and rate of planting shall be as stated in the special provision. Resprigging shall be done in a manner approved by the engineer which will cause a minimum of disturbance to the existing plants.

903-3.11 REPAIRING. When the surface has become gullied or otherwise damaged, during the period covered by this contract, the affected areas shall be repaired to reestablish the grade and the con-

dition of the soil immediately prior to planting, as directed by the engineer and provided for in this specification, and shall then be resprigged as specified in section 3.6 above. Layer placing and compacting of fill material will be in accordance with the applicable grading specifications.

METHOD OF MEASUREMENT

903-4.1 The area of ground surface preparation to be paid for shall be the number of acres and tenths thereof, measured by surface area, prepared, and accepted.

903-4.2 The area of liming to be paid for shall be the number of acres and tenths thereof, measured by surface area, limed, and accepted.

903-4.3 The area of fertilizing to be paid for shall be the number of acres and tenths thereof, measured by surface area, fertilized, and accepted.

903-4.4 The area of planting to be paid for shall be the number of acres and tenths thereof, measured by surface area, sprigged, and accepted.

903-4.5 The units of watering to be paid for shall be the number of 1,000-gallon units of water, measured by an approved meter or in the vehicle at the point of delivery, and used as specified or ordered.

903-4.6 The area of mowing to be paid for shall be the number of acres for each separate mowing operation, measured by the surface area, mowed, and accepted.

903-4.7 The area of refertilizing to be paid for shall be the number of acres for each separate refertilizing operation, measured by the surface area, refertilized, and accepted.

903-4.8 The area of resprigging to be paid for shall be the number of acres and tenths thereof, measured by the surface area, resprigged, and accepted.

903-4.9 The quantity of soil for repair work to be paid for shall be the number of cubic yards of soil, measured in the vehicle at the point of delivery, completed in place, and accepted.

BASIS OF PAYMENT

903-5.1 The acreage of ground surface preparation, determined as provided above, shall be paid for at the contract unit price per acre for "Preparing the Ground Surface," which price and payment shall constitute full compensation for removing of debris, tilling, smooth and finished grading, incorporating lime and fertilizer, cleaning up, protection, and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.2 The acreage of liming, determined as provided above, shall be paid for at the contract unit price per acre for "Liming," which price and payment shall constitute full compensation for furnishing and applying lime and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.3 The acreage of fertilizing, determined as provided above, shall be paid for at the contract unit price per acre for "Fertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.4 The acreage of planting, determined as provided above, shall be paid for at the contract unit price per acre for "Planting Sprigs," which price and payment shall constitute full compensation for furnishing (unless available on the site), harvesting, and preparation of sprigs, planting, compacting, and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.5 The units of watering, determined as provided above, shall be paid for at the contract unit price per 1,000-gallon unit for "Watering," which price and payment shall be full compensation for furnishing, hauling, and distributing water and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.6 The acreage of mowing, determined as provided above, shall be paid for at the contract unit price per acre for each "Mowing," which price and payment shall constitute full compensation for all mowing and for any required raking and removing of excessive growth, and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.7 The acreage for refertilizing, determined as provided above shall be paid for at the contract unit price per acre for "Refertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.8 The acreage for resprigging, determined as provided above, shall be paid for at the contract unit price per acre for "Resprigging," which price and payment shall constitute full compensation for furnishing (unless available on the site), harvesting, preparing, and planting sprigs; and for all labor, equipment, tools, and incidentals necessary to complete the work.

903-5.9 The yardage of soil, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Repairing," which price and payment shall constitute full compensation for furnishing, hauling, placing, spreading, and compacting soil; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- | | |
|----------------|--|
| Item T-903-5.1 | Preparing the Ground Surface—per acre. |
| Item T-903-5.2 | Liming—per acre. |
| Item T-903-5.3 | Fertilizing—per acre. |
| Item T-903-5.4 | Planting Sprigs—per acre. |
| Item T-903-5.5 | Watering—per 1,000-gallon unit. |
| Item T-903-5.6 | Mowing—per acre. |
| Item T-903-5.7 | Refertilizing—per acre. |
| Item T-903-5.8 | Resprigging—per acre. |
| Item T-903-5.9 | Repairing—per cubic yard. |

ITEM T-904 SODDING

DESCRIPTION

904-1.1 This item shall consist of preparing the ground surface, furnishing and applying lime and fertilizer, removing sod from designated areas to be stripped on the site, or furnishing sod from approved sources off the site, placing the sod on the prepared areas, finishing, watering, establishing and repairing in accordance with this specification at the locations shown on the plans or as directed by the engineer.

MATERIALS

904-2.1 SOD. Sod to be furnished by the contractor shall have a good cover of living or growing grass. This shall be interpreted to include grass that is seasonally dormant during the cold or dry seasons and capable of renewing growth after the dormant period. All sod shall be obtained from areas where the soil is reasonably fertile and contains a high percentage of loamy topsoil. Sod shall be cut or stripped from living, thickly matted turf relatively free of weeds or other undesirable foreign plants, large stones, roots or other materials which might be detrimental to the development of the sod or to future maintenance. At least seventy (70) percent of the plants in the cut sod shall be composed of the species stated in the special provisions, and any vegetation more than six (6) inches in height shall be mowed to a height of three (3) inches or less before sod is lifted. Sod, including the soil containing the roots and the plant growth showing above, shall be cut uniformly to a thickness not less than that stated in the special provisions.

904-2.2 LIME. Lime shall be ground limestone containing not less than eighty-five (85) percent of total carbonates and shall be ground to such a fineness that ninety (90) percent will pass through a No. 20 mesh sieve and fifty (50) percent will pass through a No. 100 mesh sieve. Coarser material will be acceptable, providing the rates of application are increased to provide not less than the minimum quantities stated in the special provisions on the basis of the two sieve requirements above.

904-2.3 FERTILIZER. Fertilizers shall be commercial carriers of available plant food elements or combinations thereof, either as inorganic or organic materials, as stated in the special provisions, and shall conform to the applicable State fertilizer laws. The fertilizer shall be uniform in composition, dry, and free-flowing material in condition for application by suitable equipment. The fertilizer shall be

delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable.

904-2.4 WATER. The water shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass. It shall be subject to the approval of the engineer prior to use.

904-2.5 SOIL FOR REPAIRS. The soil for fill and topsoiling of areas to be repaired shall be at least of equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps, or other material that would interfere with subsequent sodding, compacting, or establishing. All soil shall be approved by the engineer before being placed.

904-2.6 INSPECTION AND TESTS. (a) *Sod.* Sources of sod to be furnished by the contractor shall be made known to the engineer within five (5) days following acceptance of the bid, and shall be approved before moving. Sod will be inspected during laying operations, and any which fails to meet the requirements under 2.1, or which has been permitted by the contractor to dry out or become otherwise injured during the transportation or storage so that its survival after placing has been rendered doubtful, will be rejected. Thickness of the sod shall be determined by the following method. Eleven random sods shall be stacked in a pile and measured from the base of the bottom sod to the base of the uppermost sod. This measure divided by ten will be accepted as the average thickness of the sod.

If it is determined upon final inspection that the sod used was below specification requirements, or not watered or mowed as required, the engineer may require the contractor to resod the affected areas or have deducted from the contract payment an amount sufficient to cover the cost of the additional sodding material needed and the placing thereof.

(b) *Lime and Fertilizer.* The engineer shall be furnished with duplicate copies of invoices of all lime and fertilizer used on the project. Invoices for lime will show total minimum carbonates and minimum percentages of the material furnished that pass the 20-mesh and 100-mesh sieves. Invoices for fertilizer will show the kind and analysis furnished. Each lot of lime and fertilizer shall be subject to sampling and testing at the discretion of the engineer, using approved methods in determining compliance with applicable State laws.

In the event that these tests cannot be completed prior to the application of lime and fertilizer, and the tests when made show that lime and fertilizer used were below the grade of specification requirements, the contractor may be required, at the discretion of the engineer, to supply and distribute sufficient additional materials over the entire affected area to bring the amounts up to specification requirements, or have deducted from the contract payment an amount sufficient to cover the cost of such quantities of lime and fertilizer and the application thereof.

CONSTRUCTION METHODS

904-3.1 GENERAL. (a) Areas to be solid, strip, and spot-sodded will be shown on the plans. Areas requiring special ground surface preparation such as tilling, and those in a satisfactory condition to remain undisturbed, will be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface, and for handling and placing all required materials, shall be on hand, in good condition, and shall be approved by the engineer before the various operations are started. The contractor shall demonstrate to the engineer before starting the various operations that the application of required materials will be made at the specified rates.

During the operations of distributing lime or fertilizer, or laying sod, the areas covered shall be checked against the quantity of material used when one-fourth, one-half, and three-fourths of the affected areas have been covered to verify the proper rate of application. Upon completion of the distributing operations, a final check of the total quantities of materials used shall be made against the total area limed, fertilized, and sodded. If it is determined, by this checking of quantities used or by inspection immediately after distributing, that uniform distribution at rates at least equal to the minimum required has not been made, the contractor may be required, at the discretion of the engineer, either to distribute additional quantities of these materials on the areas designated to meet the specification requirements, providing seasonal conditions are favorable, or have deducted from his payment an amount sufficient to cover the cost of the material and also the cost of distributing.

(b) *Order of Work.* The order of work operations shall be as follows unless modified by special provisions:

- (1) Removing debris.
- (2) Applying lime.
- (3) Tilling.
- (4) Smooth grading.
- (5) Applying and incorporating fertilizer.
- (6) Obtaining sod.
- (7) Laying sod.
- (8) Finishing.
- (9) Watering.

904-3.2 PREPARING THE GROUND SURFACE. (a) *Removing Debris.* Prior to and during tilling or smooth grading, the ground surface shall be cleared of all stones larger than three (3) inches in greatest diameter, cable, wire or any other materials which might hinder proper tilling, smooth grading, sodding, or subsequent maintenance operations.

(b) *Tilling.* The areas to be sodded shall be thoroughly loosened to a depth of at least three (3) inches by disking, harrowing, or by other approved means. Tilling shall continue until the condition of the soil is acceptable to the engineer as suitable for sodding.

(c) *Smooth Grading.* Where final grades have been established by others, they shall be shown on the plans. Where grades have not been established, the areas shall be graded as required by plans and specifications, and the surfaces shall be left at the prescribed grades in an even and properly compacted condition which will prevent the formation of low places and pockets where excess water will stand.

904-3.3 LIMING AND FERTILIZING. (a) *Applying Lime.* Lime shall be distributed uniformly over the areas to be sodded at a rate which will provide not less than the minimum quantity stated in the special provisions. Distribution shall be by hand or by an approved distributor or other equipment satisfactory to the engineer.

(b) *Applying Fertilizer.* Fertilizer shall be distributed uniformly over the areas to be sodded at a rate which will provide not less than the minimum quantity of each fertilizer ingredient as stated in the special provisions. Distribution shall be by hand, or by a common fertilizer distributor, or other equipment approved by the engineer. Use of a grain or seed drill equipped to sow seed and distribute fertilizer at the same time will be permitted for over-seeding of areas between strip or spot sodding.

(c) *Incorporating Lime.* Following distribution, lime shall be incorporated into the soil to the full depth of tilling by disking, harrowing, or other methods acceptable to the engineer. Lime may be incorporated during the tilling operations except in the case of plowing or when otherwise stated in the special provisions.

(d) *Incorporating Fertilizer.* Following distribution, fertilizer shall be incorporated into the soil to the depth stated in the special provision. If the depth of tilling and the depth of incorporating fertilizer are the same, the incorporating may be done as a part of the tilling operation, except that inorganic fertilizer containing nitrogen shall not be applied and incorporated more than 48 hours prior to laying the sod or when otherwise stated in the special provisions. When the depth of tilling is greater than the depth of incorporating of fertilizer, the incorporating may be included as part of the disking or harrowing operations, providing it is done just prior to laying the sod.

904-3.4 OBTAINING AND DELIVERING SOD. After inspection and approval of the source of sod by the engineer, the sod shall be cut to at least the minimum thickness stated in the special provisions and divided into squares or into rectangular sections which may vary in length, but shall be of equal width, and of a size that will permit them to be lifted and transported without breaking. Mechanical devices may be used for cutting the sod. Care shall be exercised at all times to retain the native soil on the roots of the sod during the process of stripping, transporting, and placing. Dumping from vehicles shall not be permitted.

The sod shall be transplanted within twenty-four (24) hours from the time it is stripped, unless circumstances beyond the contractor's control make storing necessary. In such cases, sod shall be stacked roots-to-roots or grass-to-grass at its destination and protected from

exposure or freezing, under conditions least likely to cause spoilage and in a manner approved by the engineer. Sod shall be cut and moved only when the soil moisture conditions are such that favorable results can be expected. Where the soil is too dry, permission to cut sod may be granted only after it has been watered sufficiently to moisten the soil to the depth the sod is to be cut.

904-3.5 LAYING SOD. (a) *General.* Sodding shall be performed only during the seasons when satisfactory results can be expected. With the approval of the engineer, sod may be transplanted during periods of drought, provided the sod-bed is watered to moisten the soil to a depth of at least four (4) inches immediately prior to laying the sod.

(b) *Solid Sodding.* The sod shall be laid smoothly, edge to edge and with staggered joints. The sod shall immediately be pressed firmly into contact with the sod bed by tamping or rolling with approved equipment so as to eliminate air pockets, provide a true and even surface, and insure knitting without displacement of the sod or deformation of the surfaces of sodded areas. Screened soil of good quality shall be used to fill all cracks between sods. The quantity of fill soil shall be such as to cause no smothering of the grass. Where the grades are such that the flow of water will be from paved surfaces across sodded areas, the surface of the soil in the sod after compaction shall be set approximately one (1) inch below the pavement edge. Where the flow will be over the sodded areas and onto paved surfaces, including catch basins, the surface of the soil in the sod after compaction shall be placed flush with, or up to one (1) inch above, the pavement or inlet edges.

(c) *Strip Sodding.* Strips of sod shall be laid in continuous parallel rows at right angles to the slope or flow of water so that the centers of each sod strip are the distance apart as stated in the special provisions. Each strip of sod shall be the width stated in special provisions and shall be laid in a trench and firmly rolled or tamped. The strips shall be pressed into the sod bed so that the surface of the finished sod is below the surface of the prepared sod bed to the depth stated in the special provisions.

(d) *Spot Sodding.* Sod shall be cut into the size of blocks stated in the special provisions. The individual pieces of sod shall be placed on centers of the dimension stated in the special provisions, grass side up, and pressed firmly into the soil by foot pressure or by tamping until the surface of the piece of sod is below the soil surface to the depth stated in the special provisions. The sods may be planted in open furrows, and covered with soil up to one (1) inch, unless otherwise stated in the special provisions.

904-3.6 FINISHING. After the sod has been layed, the edges of the area shall be smoothed and shaped to conform to the cross sections previously provided and existing at the time the operations were begun. Any suitable excess material from the planting operations shall be spread uniformly over adjacent areas and the remainder

disposed of as directed by the engineer. On slopes steeper than 2 to 1 or elsewhere, as indicated on the plans, solid or strip sod shall be fastened in place with suitable wooden pins or by other methods as approved by the engineer.

904-3.7 WATERING. Watering will be required if sodding is authorized when the soil is excessively dry. Water shall be delivered through pipe and hose or in containers which will assure delivery of a full-measured quantity without waste. When water is required to be applied in furrows it shall be distributed uniformly along the bottoms of the furrows immediately before they are covered and at the rate stated in the special provisions. When water is required to be applied on the surface it shall be uniformly distributed over the area designated to be watered by means of hose sprinklers, sprinkler trucks, or other equipment approved by the engineer and at the rate stated in the special provisions. Sprinkling shall be done slowly enough to assure maximum penetration into the soil, but it shall be done rapidly enough so that the required quantity for a single application shall be delivered within a time interval not greater than that stated in the special provisions. When directed by the engineer, additional watering by the surface application method shall be done as provided above and at the rate and within the time interval stated in the special provisions. In all cases watering shall be done in a manner which will avoid erosion from the application of excessive quantities and avoid damage to the finished surface by wheel scars.

904-3.8 ESTABLISHING TURF. (a) *General.* The contractor shall provide general care for the sodded areas until the grass has become established. This period shall begin as soon as the sod has been layed and shall continue for the period stated in the special provisions.

(b) *Protection.* All sodded areas shall be protected against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricades that may be shown on the plans, before or immediately after the sod has been layed.

(c) *Mowing.* The sodded areas shall be mowed with approved mowing equipment at approximately the dates stated in the special provisions. The dates of mowing and total area to be mowed may be modified by the engineer, or by the contractor with the approval of the engineer, depending upon climatic and growth conditions and the needs for mowing of specific areas. In the event that weeds or other undesirable vegetation are permitted to grow to such an extent that, either cut or uncut, they threaten to smother the sodded species, they shall be mowed and the clippings raked and removed from the area.

904-3.9 REPAIRING. When the surface has become gullied or otherwise damaged during the period covered by this contract, the affected areas shall be repaired to reestablish the grade and the condition of the soil, as directed by the engineer, and shall then be resodded as specified in section 3.5 above. Layer placing and compacting of

fill material will be in accordance with the applicable grading specifications.

METHOD OF MEASUREMENT

904-4.1 The area of solid sodding to be paid for shall be the number of square yards, measured by surface area, solid sodded, and accepted.

904-4.2 The area of strip (or spot) sodding to be paid for shall be the number of acres or tenths thereof, measured by surface area, strip (or spot) sodded, and accepted.

904-4.3 The units of watering to be paid for shall be the number of 1,000-gallon units of water, measured by an approved meter or in the vehicle at the point of delivery, and used as specified or ordered.

904-4.4 The area of mowing to be paid for shall be the number of acres for each separate mowing operation, measured by surface area, mowed, and accepted.

904-4.5 The quantity of soil for repair work to be paid for shall be the number of cubic yards of soil measured in the vehicle at the point of delivery, completed in place and accepted.

BASIS OF PAYMENT

904-5.1 The yardage of solid sodding, determined as provided above, shall be paid for at the contract unit price per square yard for "Solid Sodding," which price and payment shall constitute full compensation for preparing the ground surface, furnishing and applying lime and fertilizer, furnishing (unless available on the site) and placing solid sod, finishing, protection; and for all labor, equipment, tools, and incidentals necessary to complete the work.

904-5.2 The acreage of strip (or spot) sodding, determined as provided above, shall be paid for at the contract unit price per acre for "Strip (or Spot) Sodding," which price and payment shall constitute full compensation for preparing the ground surface, furnishing and applying lime and fertilizer, furnishing (unless available on the site) and placing strip (or spot) sod, finishing, protection; and for all labor, equipment, tools, and incidentals necessary to complete the work.

904-5.3 The units of watering, determined as provided above, shall be paid for at the contract unit price per 1,000-gallon unit for "Watering," which price and payment shall be full compensation for furnishing, hauling, and distributing water and for all labor, equipment, tools, and incidentals necessary to complete the work.

904-5.4 The acreage of mowing, determined as provided above, shall be paid for at the contract unit price per acre for each "Mowing," which price and payment shall constitute full compensation for all mowing and for any required raking and removing of excessive growth; and for all labor, equipment, tools, and incidentals necessary to complete the work.

904-5.5 The yardage of soil, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Repairing," which price and payment shall constitute full compensation for furnishing, hauling, placing, spreading, and compacting soil; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item T-904-5.1 Solid Sodding—per square yard.

Item T-904-5.2 Strip Sodding—per acre.

Item T-904-5.2 Spot Sodding—per acre.

Item T-904-5.3 Watering—per 1,000 gallon unit.

Item T-904-5.4 Mowing—per acre.

Item T-904-5.5 Repairing—per cubic yard.

ITEM T-905 TOPSOILING

DESCRIPTION

905-1.1 This item shall consist of preparing the ground surface for topsoil application, removing topsoil from designated stock piles or areas to be stripped on the site, or furnishing topsoil from approved sources off the site, and placing and spreading the topsoil on smooth-graded areas in accordance with this specification at the locations shown on the plans or as directed by the engineer.

MATERIALS

905-2.1 TOPSOIL. Topsoil when furnished by the contractor shall be a natural friable soil, possessing characteristics of representative productive soils in the vicinity from which it is obtained. The topsoil shall be obtained from naturally well-drained areas and be reasonably free from subsoil, clay lumps, stones, or similar objects larger than two (2) inches in greatest diameter, brush, stumps, roots, objectionable weeds or litter, excess acid or alkali, or any other material or substance which may be harmful to plant growth or a hindrance to subsequent smooth grading, planting, and maintenance operations.

905-2.2 INSPECTION AND TESTS. Within ten (10) days following acceptance of the bid, the engineer shall be notified of the sources of topsoil to be furnished by the contractor. The topsoil will be inspected by the engineer to determine if the selected soil meets the requirements shown in 2.1 above, and to determine the depth to which stripping will be permitted. At the time of inspection, the contractor may be required to take representative soil samples from several locations on the area under consideration, and to the proposed stripping depths. All testing shall be done by the engineer in accordance with methods approved by the Association of Official Agricultural Chemists.

CONSTRUCTION METHODS

905-3.1 GENERAL. Areas to be topsoiled will be shown on the plans. If topsoil is available on the site, the location of the stock piles or areas to be stripped of topsoil and the stripping depths will be shown on the plans.

Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping topsoil, and for handling and placing all required materials shall be on hand and in good condition, and shall be approved by the engineer before the various operations are started.

905-3.2 PREPARING THE GROUND SURFACE. (a) *Removing Debris.* The surface of the area to be topsoiled shall be cleared of all stones larger than four (4) inches in greatest dimension, and all litter or other material which may be detrimental to proper bonding, the rise of capillary moisture, and the proper growth of the desired planting.

(b) *Tilling.* Immediately prior to dumping and spreading the topsoil on any area, the surface shall be loosened by disking or other means to a depth of at least two (2) inches to facilitate bonding of the topsoil to the covered subgrade soil. Limited areas, as shown on the plans, which are too compact to respond to these operations shall receive special scarification.

(c) *Smooth Grading.* Grades on the area to be topsoiled, which have been established by others as shown on the plans, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth-graded and the surface left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places or pockets where water will stand.

905-3.3 OBTAINING TOPSOIL. Prior to the stripping of topsoil from designated areas, any vegetation, briars, stumps and large roots, rubbish or stones found on such areas, which may interfere seriously with subsequent operations, shall be removed by grubbing, mowing, raking, or other methods approved by the engineer. Heavy sod or other cover, which cannot be incorporated into the topsoil by disking or other means so that the topsoil can be spread properly, shall be removed.

When suitable topsoil is available on the site, the contractor shall remove this material from the designated areas and to the depth as directed by the engineer. The topsoil shall be spread on areas already tilled and smooth-graded or stock-piled in areas approved by the engineer. Any topsoil stock-piled by the contractor shall be rehandled and placed without additional compensation. Any topsoil that has been stock-piled on the site by others, and is required for topsoiling purposes, shall be removed and placed by the contractor under the Item T-905, Topsoiling. When topsoil, which is to be used for topsoiling purposes, is stripped as a part of the grading operations, it shall be handled and paid for under excavation, Item P-152.

When suitable topsoil is secured off the airport site, the contractor shall locate and obtain the supply, subject to the approval of the engineer. The contractor shall notify the engineer sufficiently in advance of the beginning of operations in order that necessary measurements and tests can be made. The contractor shall remove the topsoil from approved areas and to the depth as directed. The topsoil shall be hauled to the site of the work and placed or spread as required. Any topsoil stock-piled shall be rehandled and placed without additional compensation.

905-3.4 PLACING AND SPREADING TOPSOIL. The topsoil shall be dumped in separate piles uniformly distributed on the designated areas at a rate which will provide not less than the quantity stated in the special provisions. The piles of topsoil on any given area shall be left in place until it has been determined that the minimum requirements of the specification have been met and spreading has been authorized by the engineer. The topsoil shall then be evenly spread over the areas by a blade grader or other equipment approved by the engineer. Spreading shall be carried on in such a manner that turfing operations can proceed with a minimum of soil preparation or tilling. Any irregularities in the surface, resulting from topsoiling or other operations, shall be corrected insofar as practical to prevent the formation of low places and pockets where water will stand. Topsoil shall not be placed when it or the ground surface is frozen, excessively wet, or in a condition otherwise unsatisfactory for preparation of planting surfaces or smooth grading operations.

905-3.5 CLEANING UP. After the topsoil has been spread and the area smoothed to the specified grade, the surface shall be cleared of all stones, roots, or other objects larger than two (2) inches in greatest diameter, and of all wire, brush, or other objects that may interfere with subsequent planting or maintenance operations. Any topsoil or other dirt which may be brought upon pavements as a result of hauling or handling of topsoil shall be removed from the pavement promptly.

METHOD OF MEASUREMENT

905-4.1 The yardage of topsoil (obtained on the site) to be paid for shall be the number of cubic yards of topsoil measured in its original position and stripped or excavated. The yardage of topsoil (removed from stockpile) to be paid for shall be the number of cubic yards of topsoil measured in the stockpile and removed. The pay quantities shall be computed to the lines designated by the method of average end areas of topsoil excavated or removed, placed, and accepted.

Stockpiled material to be paid for shall be the number of cubic yards measured by cross-sectioning the ground surface prior to the placing of the topsoil and later re-cross-sectioning as soon as the topsoil has been stockpiled. Pay quantities shall be computed by the method of average end areas.

905-4.2 The yardage of topsoil (obtained off the site) to be paid for shall be the number of cubic yards of topsoil measured in its original position and stripped or excavated. The pay quantities shall be computed to the lines designated by the method of average end areas of topsoil excavated, hauled, placed, and accepted.

BASIS OF PAYMENT

905-5.1 The yardage of topsoil (obtained on the site or removed from the stockpile), determined as provided above, shall be paid for

at the contract unit price per cubic yard for "Topsoiling," which price and payment shall constitute full compensation for preparing the ground surface, stripping or removing the topsoil, placing and spreading, cleaning up; and for all labor, equipment, tools, and incidentals necessary to complete the work.

905-5.2 The yardage of topsoil (obtained off the site), determined as provided above, shall be paid for at the contract unit price per cubic yard for "Topsoiling," which price and payment shall constitute full compensation for preparing the ground surface, furnishing and obtaining the topsoil, hauling, placing and spreading the topsoil, cleaning up; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item T-905-5.1 Topsoiling (Obtained on Site or Removed from Stockpile)—per cubic yard.

Item T-905-5.2 Topsoiling (Furnished from Off the Site)—per cubic yard.

ITEM T-906 TOPSOIL PLANTING

DESCRIPTION

906-1.1 This item shall consist of preparing the ground surface, furnishing and applying lime and fertilizer, removing topsoil with grass from designated areas to be stripped on the site, or furnishing topsoil with grass from approved sources off the site, placing and spreading the topsoil on smooth-graded areas, cleaning up, compacting, watering, establishing, and repairing in accordance with this specification at the locations shown on the plans or as directed by the engineer.

MATERIALS

906-2.1 TOPSOIL WITH GRASS. Topsoil with grass, when furnished by the contractor, shall be a natural, friable soil obtained from approved areas covered with a vigorous growth of the grass species stated in the special provisions. The grass shall have a healthy, thickly matted root system, and shall be contained in the topsoil when it is moved. The topsoil containing grass shall be reasonably free from subsoil, clay lumps, stones, or similar objects larger than two (2) inches in greatest diameter, brush, stumps, roots, objectionable weeds or other litter, and any other material or substance which may be harmful to plant growth or a hindrance to subsequent smooth grading, planting, and maintenance operations.

906-2.2 LIME. Lime shall be ground limestone containing not less than eighty-five (85) percent of total carbonates and shall be ground to such a fineness that ninety (90) percent will pass through a No. 20 mesh sieve and fifty (50) percent will pass through a No. 100 mesh sieve. Coarser material will be acceptable providing the rates of application are increased to provide not less than the minimum quantities stated in the special provisions on the basis of the two sieve requirements above.

906-2.3 FERTILIZER. Fertilizers shall be commercial carriers of available plant food elements or combinations thereof, either as inorganic or organic materials, as stated in the special provisions, and shall conform to the applicable State fertilizer laws. The fertilizer shall be uniform in composition, dry, free-flowing material in condition for application by suitable equipment. The fertilizer shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable.

906-2.4 WATER. The water shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass. It shall be subject to the approval of the engineer prior to use.

906-2.5 SOIL FOR REPAIRS. The soil for fill, other than topsoil with grass, to be used for repairs shall be of at least equal quality to that which exists in areas adjacent to the area to be repaired. The soil shall be relatively free from large stones, roots, stumps or other materials that will interfere with subsequent topsoil planting, compacting, or establishing operations, and shall be approved by the engineer. Topsoil with grass to be used over the fill material shall meet the requirements of section 2.1 above.

906-2.6 INSPECTION AND TESTS. (a) *Topsoil With Grass.* Within ten (10) days following acceptance of the bid, the engineer shall be notified of sources of topsoil with grass to be furnished by the contractor. The topsoil will be inspected by the engineer to determine if the selected soil and grass meet the requirements and to determine the depth to which stripping will be permitted. At the time of inspection, the contractor may be required to take representative soil samples from several locations on the area under consideration and to the proposed stripping depths. All testing shall be done in accordance with methods approved by the Association of Official Agricultural Chemists.

(b) *Lime and Fertilizer.* The engineer shall be furnished with duplicate copies of invoices of all lime and fertilizer used on the project. Invoices for lime will show total minimum carbonates and minimum percentages of the material furnished that pass the 20-mesh and 100-mesh sieves. Invoices for fertilizer will show the kind and analysis furnished. Each lot of fertilizer and lime shall be subject to sampling and testing at the discretion of the engineer, using approved methods in determining the compliance with applicable State laws.

In the event that these tests cannot be completed prior to the application of lime and fertilizer and the tests, when made, show that topsoil with grass, lime, or fertilizer used was below the grade of specification requirements, the contractor may be required, at the discretion of the engineer, to supply and distribute sufficient additional materials to bring the amounts up to specification requirements, or have deducted from the contract payment an amount sufficient to cover the cost of such quantities of topsoil with grass, lime or fertilizer, and the application thereof.

CONSTRUCTION METHODS

906-3.1 GENERAL. (a) Areas to be topsoil planted, those requiring special surface preparation such as tilling, and those in a satisfactory condition to remain undisturbed will be shown on the plans. If topsoil with grass is available on the site, the location of such areas to be stripped and the stripping depths will be shown on the plans.

Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping topsoil with grass, and for handling

and placing all required materials shall be on hand, in good condition, and shall be approved by the engineer before the various operations are started. The time interval between stripping the topsoil with grass and final compacting of this soil in place shall not exceed the time stated in the special provisions.

When conditions are such, by reason of extreme drought, excessive moisture, or other factors, that satisfactory results are not likely to be obtained, the work shall be stopped and it shall be resumed only when the desired results are likely to be obtained.

During the operations of distributing lime or fertilizer, the areas covered shall be checked against the quantity of materials used when one-fourth, one-half, and three-fourths of the affected areas have been covered to verify the proper rate of application. Upon completion of the distributing operations, a final check of the total quantities of materials used shall be made against the total acreages limed and fertilized. If it is determined, by this checking of quantities used or by inspection either immediately after distributing the materials or after there is a show of green, that uniform distribution at the minimum rates of application has not been made, the contractor may be required, at the discretion of the engineer, either to distribute additional quantities of these materials on the areas designated to meet the specification requirements, providing seasonal conditions are favorable, or have deducted from his payment an amount sufficient to cover the cost of the material and also the cost of distribution.

(b) *Order of Work.* The order of work operations shall be as follows, except as modified in the special provisions:

- (1) Removing debris.
- (2) Applying lime.
- (3) Tilling.
- (4) Smooth grading.
- (5) Obtaining topsoil with grass.
- (6) Spreading topsoil with grass.
- (7) Applying fertilizer.
- (8) Incorporating fertilizer.
- (9) Cleaning up.
- (10) Compacting.
- (11) Finished grading.
- (12) Watering.

906-3.2 PREPARING THE GROUND SURFACE. (a) *Removing Debris.* The surface of the area to be topsoiled shall be cleared of all stones larger than four (4) inches in greatest dimension, and all litter or other material which may be detrimental to proper bonding, the rise of capillary moisture, and the proper growth of the desired planting.

(b) *Tilling.* Immediately prior to dumping and spreading the topsoil on any area, the surface shall be loosened by disking or other means to a depth of at least two (2) inches to facilitate bonding of the topsoil to the covered subgrade soil. Limited areas as shown on the

plans, which are too compact to respond to these operations, shall receive special scarification.

(c) *Smooth Grading.* Grades on the areas to be topsoil-planted, which have been established by others, will be shown on the plans. Where grades have not been established, the areas shall be graded as required by plans and specifications and the surfaces shall be left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

(d) *Finished Grading.* The topsoil-planted area shall be finished graded as needed to correct irregularities in the surface due to previous operations or other causes and to restore previously established grades. Steep slopes or other areas, as shown on the plans, may be excepted from this operation. Finished grading may be accomplished in part by attaching a heavy drag to the roller, but additional smoothing operations shall be performed at an angle of approximately 45 degrees to the direction in which the roller was operated. In no case shall finished grading be delayed until grass has emerged.

906-3.3 LIMING AND FERTILIZING. (a) *Applying Lime.* Lime shall be distributed uniformly over the areas to be topsoil-planted to provide not less than the minimum quantity stated in the special provisions. Distribution shall be by hand or by an approved distributor or other equipment satisfactory to the engineer.

(b) *Applying Fertilizer.* Fertilizer shall be distributed uniformly over the areas to be topsoil-planted at a rate which will provide not less than the minimum quantities of each fertilizer ingredient, as stated in the special provisions. Distribution shall be by hand or by a common fertilizer distributor or other equipment approved by the engineer.

(c) *Incorporating Lime.* Following distribution, lime shall be incorporated into the soil to the full depth of tilling by disking, harrowing, or other methods acceptable to the engineer.

(d) *Incorporating Fertilizer.* Following distribution, fertilizer shall be incorporated into the soil to the depth stated in the special provisions by disking, harrowing, or other means approved by the engineer.

906-3.4 OBTAINING TOPSOIL WITH GRASS. Prior to stripping of topsoil with grass from the designated areas, any vegetation, briars, stumps and large roots, rubbish, or stones found on such areas which may interfere seriously with subsequent mowing operations shall be removed by grubbing, raking, or other methods approved by the engineer.

When suitable topsoil with grass is available on the site, the contractor shall remove this material from the designated areas and to the depth shown on the plans. When topsoil, which is to be used for topsoil planting, is stripped as a part of the grading operations, it shall be handled and paid for in accordance with this specification, and no payments will be made for it under Excavation, Item P-152.

The topsoil with grass, when obtained off the site, shall be stripped to a depth not greater than that which has been approved by the engi-

neer, and it shall be hauled to the planting site. Stripping shall be performed only when the soil is in a moist, friable condition, or when it has been satisfactorily watered.

906-3.5 PLACING AND SPREADING TOPSOIL WITH GRASS. The topsoil with grass shall be dumped in separate piles, uniformly distributed on the designated areas at a rate which will provide not less than the quantity stated in the special provisions. The piles of topsoil with grass on any given area shall be left in place until it has been determined that the minimum requirements of the specifications have been met and spreading has been authorized by the engineer. The topsoil with grass shall then be evenly spread over the areas by a blade grader or other equipment approved by the engineer. Any irregularities in the surface, resulting from topsoil planting or other operations, shall be corrected insofar as practical to prevent the formation of low places and pockets where water will stand. Topsoil with grass shall not be placed when it or the ground surface is frozen, excessively wet, extremely dry, or in a condition otherwise unsatisfactory for preparation of planting surfaces or finished grading operations.

906-3.6 CLEANING UP. After the topsoil with grass has been spread, and the area smoothed to the specified grade, the surface shall be cleared of all stones, roots, or other objects larger than two (2) inches in greatest diameter, and of all wire, brush, or other objects that may interfere with subsequent maintenance operations. Any topsoil or other dirt which may be brought upon pavements as a result of the hauling or handling of topsoil shall be removed from the pavement promptly.

906-3.7 COMPACTING. Immediately after the above operations have been completed, the entire area shall be compacted by means of a smooth or corrugated roller with the per linear inch weight stated in the special provisions, or a pneumatic roller that will exert equal pressure. The smooth or corrugated roller shall be equipped with a cleaner; and if the soil type is such that these rollers cannot be operated without picking up excessive soil and thereby uncovering sprigs, a pneumatic roller will be required.

906-3.8 WATERING. Watering will be required if topsoil planting is authorized when the soil moisture content of the topsoil with grass is below the minimum as stated in the special provisions. Water shall be delivered through pipe and hose or in containers which will assure delivery of a full measured quantity without waste. The water shall be applied on the surface, uniformly distributed over the area designated to be watered by means of hose sprinklers, sprinkler trucks, or other equipment approved by the engineer and at the rate stated in the special provisions. Sprinkling shall be done slowly enough to assure maximum penetration into the soil, but it shall be done rapidly enough so that the required quantity for a single application shall be delivered within a time interval not greater than that stated in the special provisions. When directed by the engineer, additional watering shall be done as provided above and at the rate

and within the time interval stated in the special provisions. In all cases watering shall be done in a manner which will avoid erosion due to the application of excessive quantities and which will avoid damage to the finished surface by wheel scars.

906-3.9 ESTABLISHING TURF. (a) *General.* The contractor shall be responsible for the proper care of the topsoil-planted areas during the period when the grass is becoming established. This period shall begin immediately after planting and shall continue for the period stated in the special provisions.

(b) *Protection.* The contractor shall protect the area against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricades that may be shown on the plans before or immediately after topsoil planting is completed.

(c) *Mowing.* The topsoil-planted areas shall be mowed with approved mowing equipment at approximately the dates stated in the special provisions. The dates of mowing and total area to be mowed may be modified by the engineer, or by the contractor with the approval of the engineer, depending upon climatic and growth conditions and the needs for mowing of specific areas. In the event that weeds or other undesirable vegetation grow to such an extent that, either cut or uncut, they threaten to smother the planted species, they shall be mowed, and the clippings raked and removed from the area.

(d) *Refertilizing.* Areas needing refertilization shall be designated by the engineer at least fifteen (15) days prior to the time application is required. The fertilizer shall be distributed by common broadcast fertilizer spreader during a period when the plants are dry, and in a manner approved by the engineer, which will cause a minimum of disturbance to the plants. The fertilizer shall be the kind or grade as stated in the special provisions under paragraph 2.3.

Fertilizer shall be distributed uniformly over the areas designated by the engineer to be refertilized at a rate which will provide not less than the minimum amounts of the fertilizer ingredient, as stated in the special provisions. Where more than one fertilizer ingredient is required they shall be applied as separate operations at a time interval not less than that stated in the special provisions. If serious "burning" of the turf develops from the first application, or when climatic conditions indicate that there is a definite threat of "burning," the following applications will be delayed beyond the interval stated in the special provisions in order to avoid excessive damage.

906-3.10 REPAIRING. When the surface has become gullied or otherwise damaged during the period covered by this contract, the affected areas shall be repaired to re-establish the grade and the condition of the soil immediately prior to topsoil planting, as directed by the engineer and provided for in this specification, and shall then be topsoil-planted as specified in section 3.5 above. Layer placing and compacting of fill material will be in accordance with the applicable grading specification.

METHOD OF MEASUREMENT

906-4.1 The area of topsoil planting to be paid for shall be the number of acres and tenths thereof, measured by surface area, topsoil planted and accepted.

906-4.2 The area of liming to be paid for shall be the number of acres and tenths thereof, measured by surface area, limed and accepted.

906-4.3 The area of fertilizing to be paid for shall be the number of acres and tenths thereof, measured by surface area, fertilized and accepted.

906-4.4 The units of watering to be paid for shall be the number of 1,000-gallon units of water measured by an approved meter, or in the vehicle at the point of delivery, and used as specified or ordered.

906-4.5 The area of mowing to be paid for shall be the number of acres for each separate mowing operation, measured by the surface area, mowed and accepted.

906-4.6 The area of refertilizing to be paid for shall be the number of acres for each separate refertilizing operation, measured by the surface area, refertilized, and accepted.

906-4.7 The quantity of soil for repair work to be paid for shall be the number of cubic yards of soil, measured in the vehicle at the point of delivery, completed in place, and accepted.

BASIS OF PAYMENT

906-5.1 The acreage of topsoil planting, determined as provided above, shall be paid for at the contract unit price per acre for "Topsoil Planting," which price and payment shall constitute full compensation for preparing the ground surface, furnishing (unless available on the site) and obtaining topsoil with grass, placing and spreading topsoil with grass, cleaning up, compacting, finished grading, protection; and for all labor, tools, and incidentals necessary to complete the work.

906-5.2 The acreage of liming, determined as provided above, shall be paid for at the contract unit price per acre for "Liming," which price and payment shall constitute full compensation for furnishing and applying lime; and for all labor, equipment, tools, and incidentals necessary to complete the work.

906-5.3 The acreage of fertilizing, determined as provided above, shall be paid for at the contract unit price per acre for "Fertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer; and for all labor, equipment, tools, and incidentals necessary to complete the work.

906-5.4 The units of watering, determined as provided above, shall be paid for at the contract unit price per 1,000-gallon unit for "Watering," which price and payment shall be full compensation for furnishing, hauling, and distributing water; and for all labor, equipment, tools, and incidentals necessary to complete the work.

906-5.5 The acreage of mowing, determined as provided above, shall be paid for at the contract unit price per acre for each "Mowing,"

which price and payment shall constitute full compensation for all mowing and for any required raking and removing of excessive growth; and for all labor, equipment, tools, and incidentals necessary to complete the work.

906-5.6 The acreage for refertilizing, determined as provided above, shall be paid for at the contract unit price per acre for "Refertilizing," which price and payment shall constitute full compensation for furnishing and applying fertilizer; and for all labor, equipment, tools, and incidentals necessary to complete the work.

906-5.7 The yardage of soil, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Repairing," which price and payment shall constitute full compensation for furnishing, hauling, placing, spreading, and compacting soil; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- | | |
|----------------|---------------------------------|
| Item T-906-5.1 | Topsoil Planting—per acre. |
| Item T-906-5.2 | Liming—per acre. |
| Item T-906-5.3 | Fertilizing—per acre. |
| Item T-906-5.4 | Watering—per 1,000-gallon unit. |
| Item T-906-5.5 | Mowing—per acre. |
| Item T-906-5.6 | Refertilizing—per acre. |
| Item T-906-5.7 | Repairing—per cubic yard. |

ITEM T-907 TILLING

DESCRIPTION

907-1.1 This item shall consist of preparing the surface of areas for dust control or erosion control, in accordance with this specification at the locations shown on the plans, or as directed by the engineer.

CONSTRUCTION METHODS

907-3.1 GENERAL. Areas to be tilled and areas requiring special attention and tilling will be shown on the plans.

The tilling work shall be performed only during periods when beneficial and satisfactory results can be reasonably expected. The work shall be stopped when it is unlikely that the desired results will be obtained, due to excessive drought, moisture conditions, or other factors, and resumed only when the conditions again are favorable.

Suitable equipment necessary for proper tilling and for handling all required materials shall be on hand, in good operating condition, and shall be approved by the engineer before the various operations are started.

907-3.2 TILLING. (a) *General.* Prior to the commencement of tilling operations, all heavy growths of vegetation on areas shown on the plans to be tilled shall be mowed, raked and burned, used for mulch if suitable, or hauled off the site, as directed by the engineer.

During tilling operations, the ground surface shall be kept cleared of all cable, wire, or any other waste materials which might hinder final grading, planting, or subsequent maintenance operations. Any irregularities in the surface, resulting from tilling or other operations of the contractor, shall be corrected insofar as practical to prevent the formation of low places and pockets where water will stand.

The properly graded areas shall be tilled by the contractor with suitable plows, disks, scarifying machines, or other power-drawn implements approved by the engineer.

(b) *For Dust and Erosion Control.* The areas to be tilled for dust or erosion control shall be loosened to a depth of at least four (4) inches by a tiller tool in such a manner that clods will be left on the surface of the ground. In areas where such penetration cannot be accomplished by a tiller tool in one operation, a heavy scarifier shall be used first. On areas 250 feet or more from the centerline of runways, as shown on the plans, on which scarifiers will not produce clods of sufficient size and quantity to provide adequate control by the above operation, furrows shall be opened on approximately 36-inch centers

to a depth of five (5) inches by using an approved type lister. Tilling operations shall commence on the windward side of the field and at right angles to the prevailing wind except on runway shoulders, where they shall be parallel to the pavements. Equipment and operations, other than those specified above, may be used subject to the approval of the engineer.

907-3.3 SMOOTH GRADING. Where final grades have been established by others, they shall be shown on the plans. Where grades have not been established, the areas shall be smooth graded and the surfaces left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

METHOD OF MEASUREMENT

907-4.1 The area of tilling to be paid for shall be the number of acres, measured by surface area, tilled, smooth graded, and accepted.

BASIS OF PAYMENT

907-5.1 The acreage of tilling, determined as provided above, shall be paid for at the contract unit price per acre for "Tilling," which price and payment shall constitute full compensation for any necessary removing of vegetation, tilling, smooth grading, cleaning up; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item T-907-5.1 Tilling—per acre.

ITEM T-908 MULCHING

DESCRIPTION

908-1.1 This item shall consist of preparing the ground surface, furnishing and placing mulch, or remulching on the prepared areas in accordance with this specification at the locations shown on the plans, or as directed by the engineer.

MATERIALS

908-2.1 MULCH MATERIAL. Acceptable mulch shall be the materials listed below, or any approved locally available material that is similar to those specified. Low grade, musty, spoiled, partially rotted hay, straw, or other materials unfit for animal consumption will be acceptable. Mulch materials, which contain matured seed of species which would volunteer and be detrimental to proposed overseeding, or to surrounding farm land, will not be acceptable. Straw or other mulch material which is fresh and excessively brittle, or which is in such an advanced stage of decomposition as to smother or retard the planted grass, will not be acceptable.

(a) *Hay.* Hay shall be native hay, Sudan grass hay, broomsedge hay, legume hay, or similar hay or grass clippings.

(b) *Straw.* Straw shall be the threshed plant residue of oats, wheat, barley, rye, or rice from which grain has been removed.

(c) *Stalks.* Stalks shall be the whole or shredded stems of corn, cane, kafir, sorghum, broom corn, hemp, flax, sunflowers, castor beans, potato vines, tobacco, and other coarse stemmy material.

(d) *Manure.* Manure shall be fresh or partially decomposed strawy stable manure containing not over twenty-five (25) percent of solid material by volume.

(e) *Forest Litter.* Forest litter shall be the surface layer of leaves, twigs, needles, and small branches from local woods. Forest litter shall be removed in such a way as to avoid injury to the trees.

(f) *Hay Mulch Containing Seed.* Hay mulch shall be mature hay containing viable seed of native grasses or other desirable species stated in the special provisions or as approved by the engineer. The hay shall be cut and handled in such a way as to preserve the maximum quantity of viable seed. Hay mulch which cannot be hauled and spread immediately after cutting shall be placed in weather-resistant stacks or baled and stored in a dry location until used.

908-2.2 INSPECTION. Within five (5) days after acceptance of the bid, the engineer shall be notified of sources and quantities of

mulch materials available, and the contractor shall furnish him with representative samples of the materials to be used. These samples with the approval of the engineer may be used as standards; and any materials brought on the site which do not meet these standards may be rejected.

CONSTRUCTION METHODS

908-3.1 GENERAL. The areas to be mulched, and their respective requirements for mulch and special treatment, will be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface and for handling and placing all required materials shall be on hand, in good condition, and shall be approved by the engineer before the various operations are started. The contractor shall demonstrate to the engineer before starting the various operations that the application of mulch will be made at the specified rates.

908-3.2 PREPARATION OF THE GROUND SURFACE.

(a) *Removing Debris.* Prior to the commencement of tilling and smooth grading, all large stones, cable, wire, or any other materials shall be removed from the area. All heavy growths of vegetation on the site which may interfere seriously with tilling, mulching, or planting operations shall be mowed, raked and burned, used for mulch if suitable, or hauled off the site, as directed by the engineer.

During tilling operations, the exposed ground surface shall be cleared of all large stones, cable, wire, or any other waste materials which might hinder the retention of mulch or subsequent seeding or sprigging and maintenance operations.

(b) *Tilling.* The areas to be mulched shall be loosened to the depth stated in the special provisions by a one-way disk plow, offset-disk harrow, improved spring tooth harrow mounted on wheels, soil pulverizer, duck-foot cultivator, or other suitable equipment, and in a manner favorable for anchoring mulch in the soil. Insofar as practical, tilling shall be performed immediately prior to mulching operations, and in no case shall precede these operations by more than sixteen (16) hours, unless otherwise approved by the engineer.

Any irregularities in the surface, resulting from tilling or other operations of the contractor, shall be corrected insofar as practical to prevent the formation of low places and pockets where water will stand.

(c) *Smooth Grading.* Where final grades have been established by others, they shall be shown on the plans. Where grades have not been established, the areas shall be graded as required by plans and specifications, and the surfaces shall be left at the prescribed grades in an even and properly compacted condition which, insofar as practical, will prevent the formation of low places and pockets where water will stand.

908-3.3 PLACING MULCH. The mulch shall be spread uniformly in a continuous blanket at a rate which will provide not less than the quantity stated in the special provisions. The mulch shall

be spread by hand, or by a manure spreader, a modified grain combine with straw-spreader attachment, or other suitable equipment. Any large bunches of mulch which may be detrimental to future turfing operations or to the growth of seedlings shall be scattered by hand. Mulching shall be started at the windward side of relatively flat areas, or at the upper part of a steep slope, and shall continue until the area is completely and uniformly covered.

908-3.4 ANCHORING MULCH. Immediately following the spreading of the mulch, the material shall be anchored to the soil by a V-type wheel land packer, a heavy disk harrow set to cut only slightly, or other similar equipment which will secure the mulch firmly in the ground to form a soil-binding mulch and prevent loss or bunching of the mulch by wind. The number of passes over the mulch needed to secure it firmly to the soil will be determined by the engineer, but in no case shall it exceed three passes.

On slopes where machinery cannot be used satisfactorily, mulch shall be retained in place by a shallow covering of earth, or by twine, stakes, brush, or by other suitable means which will not be detrimental to subsequent maintenance. When an earth cover is used for holding mulch in place, and seed, fertilizer, and lime are required to be used, these may be mixed with the soil before covering the mulch.

908-3.5 REMULCHING. When the mulching material has been removed from an area previously mulched, due to wind, erosion, or other causes not due to the contractor's negligence, the areas shall be repaired to reestablish the surface condition specified, or as directed by the engineer.

908-3.6 PROTECTION. The contractor shall protect the area against traffic or other use by placing warning signs, as approved by the engineer, and erecting any barricades that may be shown on the plans before or immediately after mulching has been completed on the designated areas.

METHOD OF MEASUREMENT

908-4.1 The area of mulching to be paid for shall be the number of acres and tenths thereof, measured by surface area, mulched and accepted.

BASIS OF PAYMENT

908-5.1 The acreage of mulching, determined as provided above, shall be paid for at the contract unit price per acre for "Mulching," which price and payment shall constitute full compensation for preparing the ground surface, furnishing, placing and anchoring mulch, remulching, and protection; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

Item T-908-5.1 Mulching—per acre.

ITEM T-950 PLANTING TREES, SHRUBS, AND VINES

DESCRIPTION

950-1.1 This item shall consist of furnishing all material, equipment, and labor required for planting trees, shrubs, and vines as specified herein at the locations shown on accompanying planting plans, or designated by the engineer.

MATERIALS

950-2.1 TOPSOIL. Topsoil, if required, shall be a natural fertile, friable soil possessing characteristics of representative productive soils in the vicinity. It shall be obtained from naturally well-drained areas and be reasonably free from subsoil, clay lumps, stones, stumps, roots, or similar substances two (2) inches or more in diameter or other objects which might be a hindrance to planting operations. It shall not be excessively acid or alkaline nor contain toxic substances which may be harmful to plant growth.

950-2.2 PEAT. Peat, if required, shall consist of not less than sixty (60) percent partially decomposed organic matter, by weight, on an oven-dried basis. It shall be delivered to the site in a loose, workable condition.

950-2.3 MANURE. Manure, if required, shall be well-rotted unleached stable or cattle manure, reasonably free from shavings, sawdust, or refuse, and shall not contain harmful materials.

950-2.4 LIME. Lime, if required, shall be ground limestone containing not less than eighty-five (85) percent of total carbonates, and shall be ground to such fineness that fifty (50) percent will pass through a No. 100 mesh sieve and ninety (90) percent will pass through a No. 20 mesh sieve. Coarser material will be acceptable, provided the specified rates of application are increased proportionately on the basis of quantities passing the No. 100 mesh sieve.

950-2.5 INORGANIC FERTILIZER. The fertilizer shall be a grade of inorganic fertilizer, as stated in the special provisions, and shall conform to the applicable State fertilizer laws. It shall be uniform in composition, dry and free-flowing, and shall be delivered to the site in the original, unopened containers, each bearing the manufacturer's guaranteed analysis. Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be accepted.

950-2.6 WATER. The water shall be free from any chemical or physical contents, including oil, acid, alkali, salt, or other material,

which are harmful to plants. It shall be subject to the approval of the engineer prior to its use.

950-2.7 DRAIN TILE. Drain tile, if required, shall be first quality, hard-burned, agricultural tile, four (4) inches inside diameter.

950-2.8 GUYING AND STAKING MATERIALS. Wires for guying trees shall be black iron of number twelve (12) gauge. Stakes for supporting trees or for anchoring guy wires and deadmen for anchoring wires shall be of sound wood, either squared lumber or natural round poles, and shall be of the sizes specified hereinafter.

950-2.9 MULCH. Mulch shall consist of peat, forest litter, hay, or other suitable materials, and shall be of such a character as not to be easily displaced by wind.

950-2.10 WRAPPING MATERIAL. Wrapping material for tree trunks shall be standard burlap, heavy crepe paper, or cloth. It shall be in strips six (6) to ten (10) inches wide.

950-2.11 PLANTS. (a) *Nomenclature.* The scientific and common names of plants required under this contract are in conformity with the approved names given in Standardized Plant Names, 1942 edition, prepared by the American Joint Committee on Horticultural Nomenclature.

(b) *Quality and Size.* Plants shall be in accordance with Horticultural Standards, 1941 edition, of rules and grading adopted by the American Association of Nurserymen. All plants shall have a habit of growth that is normal for the species and shall be sound, healthy, and vigorous, and free from insect pests, plant diseases, sun scalds, or fresh abrasions of the bark. Any tree with a weak, thin trunk not capable of supporting itself when planted in the open will not be accepted. All plants shall conform to the measurements specified in the List of Required Plants contained in the special provisions, which are minimum acceptable sizes. They shall be measured before pruning, with branches in normal position. Plants larger in size than specified may be used if approved by the engineer, but the use of larger plants will make no change in the contract price. If the use of larger plants is approved, the ball of earth or spread of roots shall be increased proportionately.

(c) *List of Required Plants.*

TREES

Item number	Scientific and common names	Spread of branches (feet)	Caliper (inches)	Type of root protection required ¹	Source ²	Quantity

(As stated in the special provisions.)

¹ B & P=Balled and platformed. B & B=Balled and burlapped. BR=Bare root.

² N=Nursery grown. Col=Collected.

SHRUBS

Item number	Scientific and common names	Spread of branches (feet)	Height (feet)	Type of root protection required ¹	Source ²	Quantity
Stakes						

(As stated in the special provisions.)

HEDGE PLANTS

Item number	Scientific and common names	Number of canes	Height (feet)	Type of root protection required ¹	Source ²	Quantity

(As stated in the special provisions.)

VINES

Item number	Scientific and common names	Length of runners (inches)	Number of runners	Type of root protection required ¹	Source ²	Quantity

(As stated in the special provisions.)

¹ B & P=Balled and platformed. B & B=Balled and burlapped. BR=Bare root.

² N=Nursery grown. Col=Collected.

(d) *Substitutions.* No substitutions shall be made without the written consent of the engineer. Plants of other kinds to be used in lieu of those named in the List of Required Plants, however, will be accepted provided, in the opinion of the engineer, the proposed substitute, in each case, possesses the same essential characteristics as the kind of plant actually specified in regard to size, shape, habit or growth, soil and other horticultural requirements, retentiveness of leaves and general appearance. Partial substitution or the substitution of more than one kind of plant in place of a given plant specified may be accepted, if the requirements detailed above are met.

(e) *Type of Protection to Roots.* 1. Balled and Platformed Plants. Plants designed "B&P" in the List of Required Plants shall be balled and platformed. They shall be dug with firm, natural balls of soil of adequate size, the balls firmly wrapped with burlap or similar material and bound with twine, cord or wire, and mounted on

sturdy platforms with the platforms securely bound to the balls. No balled plant shall be planted if the ball is cracked or broken either before or during the process of planting.

2. **Balled and Burlapped Plants.** Plants designated "B&B" in the List of Required Plants shall be adequately balled with firm, natural balls of soil of sufficient size to assure the continued growth of plants. Balls shall be firmly wrapped with burlap or similar material and tightly bound with twine, cord, or wire in such a manner as to hold the balls firm and intact. No balled plant shall be planted if the ball is cracked or broken either before or during the process of planting.

3. **Bare-Root Plants.** Plants designated "BR" in the List of Required Plants shall be dug with reasonable care and skill and with the major portion of the root system intact, but with the earth carefully removed from the roots. The roots of these plants shall be protected at all times to prevent excessive drying, loss of vitality, and unnecessary injury. They either shall be covered with a thick coating of mud by puddling or carefully protected with wet straw, moss, or other suitable packing material which will assure the arrival of plants at the destination in good condition.

950-2.12 INSPECTION AND TESTS. Within ten (10) days following acceptance of the bid, the engineer shall be notified of the sources of the materials to be furnished by the contractor.

(a) *Topsoil.* If topsoil is required, the engineer will inspect it to determine whether or not it meets the requirements as stated in paragraph 2.1 and to approve the depth to which it may be stripped. At the time of the inspection, the contractor may be required to take representative soil samples, under the direction of the engineer, to the proposed stripping depth, from several locations on the area under consideration. These samples will be tested for pH (or lime requirements), organic matter content, and available phosphoric acid and potash. Testing shall be done by a State or commercial soil testing laboratory using methods approved by the Association of Official Agricultural Chemists or the State Agricultural Experiment Station.

(b) *Inorganic Fertilizer and Lime.* Copies of invoices of all inorganic fertilizer and lime used on the project shall be furnished in duplicate to the engineer. Invoices for fertilizer shall show the grade of fertilizer supplied. Invoices for lime shall show total minimum carbonates and minimum percentages of the material furnished that pass the No. 100 and No. 20 mesh sieves. Each lot of fertilizer and lime shall be subject to sampling and testing, at the discretion of the engineer, using approved methods applicable in determining compliance with State fertilizer laws and requirements.

(c) *Plants.* The contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants. All plants shall be subject to inspection and approval by the engineer at any place or at any time. Plants may be inspected where growing, but

approval at the place of growth shall not preclude the right of rejection at the site.

(d) *Other Materials.* Representative samples of other materials to be used on the project shall be furnished by the contractor to the engineer at least five (5) days prior to their use on the project. All materials shall be subject to inspection and approval by the engineer at any time.

CONSTRUCTION METHODS

950-3.1 PLANTING SEASON. The planting season shall be as stated in the special provisions, except as otherwise directed in writing by the engineer. Planting operations shall be suspended when planting conditions, weather, or other factors are unfavorable for successful planting, at the discretion and order of the engineer; operations shall be resumed upon order of the engineer.

950-3.2 PLANTING OPERATIONS. (a) *Protection Against Drying Out.* All plants shall be handled so that the roots are adequately protected at all times from drying out or from other injury. The balls of balled and burlapped plants which are not planted immediately on delivery shall be well protected with moist soil or other acceptable material. If bare-rooted plants are not planted on delivery, they shall be heeled-in immediately in moist soil and kept watered as necessary until planted.

(b) *Lay-out.* Locations for plants and outlines of areas to be planted shall be suitably marked on the ground by the contractor before any excavation is made. All plant locations shall be in accordance with the planting plan and approved by the engineer.

(c) *Pits and Beds.* Planting pits and beds shall be prepared before or concurrently with digging of the plants so that no delay will occur as a result of the planting areas not being ready. All plant materials shall be planted in pits, except those specifically designated on the plans to be planted in beds.

1. *Obstructions Below Ground.* Rock or any other obstruction which interferes with proper depth of planting, as specified and in accordance with the planting plans, shall be removed. If underground construction, obstructions, or rock, which cannot feasibly be removed, is encountered in the excavation of planting areas, other locations for the plantings may be selected by the engineer. Explosives may be used only where and as expressly approved by the engineer.

2. *Shape and Size.* All plant pits shall be circular in outline, have vertical sides and flat bottoms. The depths of plant pits, specified below, shall be measured from finished grade. The outline of each planting bed shall be in accordance with the plans, except where minor deviations may be specifically authorized by the engineer. Minimum depth of pits for trees shall be two (2) feet, and this depth shall be increased as much as may be necessary to accommodate the ball or roots when the tree is set to finished grade. Diameter of pits for trees shall be at least two (2) feet greater than the diameter of the ball, container, or spread of roots. Minimum depth of pits for all shrubs

and vines shall be sixteen (16) inches, and this depth shall be increased as much as may be necessary to accommodate the ball or roots when the plant is set to grade. Diameter of pits for all shrubs and vines, except those supplied bare-rooted (BR), shall be at least two (2) feet greater than the ball. Bare-rooted shrubs and vines shall be planted in pits at least one (1) foot greater in diameter than the spread of roots.

3. **Drainage.** Tile subsoil drainage shall be provided as indicated on the planting plans. Before operations are begun, the contractor shall stake and set grades for all tile-line installations. These grades will be checked by the engineer. Trenches shall be dug with vertical sides, and shall be at least twelve (12) inches wide and not less than eighteen (18) inches deep below finished grades. A trough, shaped to hold the tile, shall be dug along the central portion of the bottom of the trenches. Drain tile shall be firmly bedded, laid true to grade, with a minimum slope of one-fourth ($\frac{1}{4}$) inch per foot away from the pit, and shall be laid to a dry-well or other suitable outlet, as approved by the engineer. All dead ends shall be sealed with a flat stone, a flat piece of concrete, or other suitable material. Joint openings shall not exceed one-eighth ($\frac{1}{8}$) inch, and shall be covered with a strip of felt or tar paper over at least the top half of the tile so as to prevent ingress of soil. A layer of acceptable porous material, such as cinders, crushed rock, or gravel four (4) inches deep shall be placed over each tile line, after which the trench shall be backfilled with soil and well-compacted in layers not exceeding eight (8) inches.

4. **Soil Preparation.** Soil used for backfilling in planting areas shall be either topsoil, as hereinbefore specified, or suitable existing soil mixed with peat and manure, as directed by the engineer. Mixed soil for all plants shall consist of one part of peat and one part of manure to five parts of existing soil. Very poor soils, or those containing hard-pan or other soil injurious to plants, shall not be used. The peat and manure shall be thoroughly mixed with the existing soil before being placed into the pits. Planting beds shall be prepared as follows: Peat and manure shall be spread uniformly over the bed, each to a depth of one (1) inch, after which they shall be thoroughly mixed and incorporated with the upper six (6) inches of existing soil. The mixed soil in beds shall be moist, but shall not contain excessive water to cause puddling or undue compaction, at the time plants are set.

5. **Disposal of Excess Soil.** Excess excavated soil shall be disposed of where and as directed by the engineer.

(d) **Setting Plants.** Before setting plants a minimum of three (3) inches of topsoil or prepared soil as described above, shall be placed in the pits. Plants shall be set at such level that, after settlement, they will bear the same relation to the level of the surrounding ground as they bore to the ground from which they were dug; they shall be planted upright and faced to give the best appearance. In the case of balled plants all burlap, cloth, twine, wire, etc., shall be removed from the tops and sides of the balls, but no burlap or cloth shall be

pulled out from under the balls. Roots of bare-root plants shall be spread out to approximately their original position, and topsoil carefully worked in among them. All broken or frayed roots shall be cut off cleanly. The backfill shall be put in and tamped in successive eight (8) inch layers. When the hole has been nearly filled, water shall be poured in and allowed to soak away so that all voids or air pockets under or around the roots are eliminated. After the water has soaked down, the hole shall be filled with suitable soil. A shallow saucer, capable of holding water, shall be formed around each plant by placing a mound of topsoil around the edge of each pit. After the ground settles, additional soil shall be filled in to the level of the finished grade.

(e) *Pruning.* The amount of pruning shall be limited to the minimum necessary to remove injured twigs and branches and to compensate for the loss of roots as a result of transplanting operations. Pruning shall be done in such a manner as not to change the natural habit or shape of the plant. With the approval of the engineer, pruning may be done before delivery of plants. All cuts shall be made flush, leaving no stubs. Cuts over three-fourths ($\frac{3}{4}$) inch in diameter and any bruises or scars on the bark shall be painted with tree-wound paint.

(f) *Staking and Guying.* Trees up to three (3) inches in diameter which are planted on the outer edges of planting masses, or isolated, shall be supported by two or three stakes. Stakes shall be driven three (3) to four (4) feet into the ground at a distance of about three (3) feet from the trunk of the tree. The tree shall be fastened, at a height of about five (5) feet, to each stake by means of short lengths of garden hose through which wire has been strung, or by strips of webbing or soft rope. Only a single loop for each fastening to the trunk shall be used, and it shall never be tight enough that the trunk will be constricted. Trees three (3) to six (6) inches in diameter, unless planted on the inside of planting masses, shall be guyed to prevent displacement. Guying shall be done with three (3) guys spaced equally about each tree. Each guy shall consist of two (2) strands of number twelve (12) gauge wire attached to the tree trunk at an angle of about forty-five (45) degrees, at about two-fifths ($\frac{2}{5}$) of the height of the tree, and anchored at the ground to notched stakes approximately two (2) inches by four (4) inches by three (3) feet, which have been driven into the ground at a slight angle away from the tree, to within six (6) inches of the tops of the stakes. Attachment to tree trunks shall be made with lag hooks or eyes, or with wire loops separated from the bark by rubber hose, heavy cloth padding, or wood staves. If lag hooks or eyes are used, there shall be at least eight (8) inches difference in their height to prevent weakening of the tree. Guys shall be tightened by twisting the strands together. Trees over six (6) inches in diameter shall be guyed with four (4) guys of one-fourth ($\frac{1}{4}$) inch cable, equally spaced about the tree, and anchored at the ground to deadmen which shall be approximately two (2) inches by four (4) inches by four (4) feet and sunk at least two (2) feet below finished grade. Cables shall be kept taut by means of turn-

containers, or spread of roots. Minimum depth of pits for all shrubs

buckles. In order to avoid accidents a strip of lath, garden label, or similar material painted white, approximately one (1) inch wide and five (5) inches long, shall be securely fastened to each guy at a uniform height of approximately two (2) feet above the ground.

(g) *Wrapping.* Promptly after planting, the trunks of all deciduous thin-barked trees shall be wrapped spirally from the groundline to the height of the second branches, or to the height directed by the engineer, using burlap or heavy crepe paper strips six (6) to ten (10) inches wide which shall be securely tied with twine.

(h) *Mulching.* All plants shall be mulched with a two (2) inch layer of mulch material within two (2) days after planting. This mulch shall entirely cover the saucer around each plant.

950-3.3 TRANSPLANTING. Existing trees or shrubs, which have been designated for utilization elsewhere on the project, shall be moved from their original location prior to construction operations, when so directed by the engineer. Procedures for transplanting, which are not described within this specification, shall be in accordance with standard nursery practices. Collected plants to be moved from their original site shall have a ball of earth or spread of roots at least one-sixth ($1/6$) greater in diameter than specified for similar-size nursery-grown plants. New locations for such trees and shrubs shall be as designated on the accompanying planting plans.

950-3.4 ESTABLISHMENT. The period of establishment shall begin immediately after planting and shall continue until the date stated in the special provisions. The soil surrounding the roots shall be saturated often enough to keep it moist at all times but shall not be excessively watered causing a waterlogged condition. Cultivating, pruning, tightening of guys, spraying, and other operations shall be performed as necessary to keep the plants in a vigorous thriving condition. During the last thirty (30) days of the establishment period, the contractor shall apply the kinds and quantities of fertilizer and lime to each plant as stated in the special provisions:

Item number	Scientific name	Name of fertilizer	Amount	Lime	Amount

(As stated in the special provisions.)

Fertilizers and lime shall be applied by cultivating them into the top two (2) inches of soil within the planting saucer. Mulch shall first be raked back, fertilizer and lime applied, and mulch replaced. The ring of earth shall also be rebuilt at any points where it may have been broken.

950-3.5 REPLACEMENT. During the establishment period, plants which die or which, in the opinion of the engineer, are in an unhealthy or badly impaired condition shall be replaced by the con-

tractor as soon as it is feasible after their unsatisfactory condition is evident. Replacements shall not be made in any season definitely unfavorable for planting the kinds of plants involved. At the conclusion of the establishment period the engineer will make an inspection of the work to determine the condition of plants. All plants then not in a healthy, growing condition will be noted and the contractor so advised. As soon as seasonal conditions permit, all plants so noted and which are still not in a healthy, growing condition, shall be removed from the site and replaced with plants of the same kinds and sizes as originally specified. Such replacements shall be made in the same manner as specified for the original planting; the cost to be borne by the contractor.

950-3.6 CLEAN-UP. Any soil, manure, peat, or similar material which has been brought onto paved areas by hauling operations or otherwise shall be removed promptly, keeping these areas clean at all times. Upon completion of the planting, all excess soil, stones, and debris which has not previously been cleaned up shall be removed from the site or disposed of, as directed by the engineer. All ground areas disturbed as a result of planting operations shall be restored to their original condition or to the desired new appearance, as directed by the engineer.

METHOD OF MEASUREMENT

950-4.1 Trees, shrubs, and vines shall be measured in units of each plant delivered and planted. The list showing the quantities and unit costs of plants shall be listed and numbered in accordance with the List of Required Plants, as contained in the special provisions. Materials such as topsoil, peat, manure, inorganic fertilizer, lime, water, and drain tile and materials for guying, staking, mulching, and wrapping shall be considered as incidental to the planting operations. Measurement for transplanting existing trees and shrubs shall be in units of each plant satisfactorily transplanted.

BASIS OF PAYMENT

950-5.1 Payment for trees, shrubs, hedge plants, and vines will be made on the basis of unit contract prices for plants accepted at the time of final inspection. Such payment shall include costs of inspecting; furnishing and planting trees, shrubs, and vines; furnishing and incorporating topsoil, peat, manure, inorganic fertilizer, lime, water, and drain tile as specified herein; furnishing materials and labor for guying, staking, mulching, pruning, and wrapping; and establishment of plants until the time of final inspection. It shall include all labor, equipment, tools, and incidentals necessary to complete the planting operations. Payment for transplanting existing trees and shrubs will be made at the contract price for each plant satisfactorily transplanted. Such payment shall include furnishing all materials, labor, and equipment necessary for this operation.

Payment will be made under:

Item T-950-5.1 Trees, Shrubs, Hedge Plants, or Vines—per unit.

ITEM T-951 TREE WELLS AND ROOT PROTECTION

DESCRIPTION

951-1.1 This item shall consist of furnishing all material, equipment, and labor required for the spreading of the porous aggregate layer, and for the construction of tree wells for the protection of selected trees or shrubs as specified herein at locations shown on the plans.

MATERIALS

951-2.1 STONE. If required, the material for tree wells shall consist of clean, hard, stones of a kind known to be durable, and shall be subject to the approval of the engineer. Stones, except those used in pinning and filling interstices in the heart of walls, shall have minimum thicknesses of six (6) inches, minimum widths of twelve (12) inches, and minimum lengths of fifteen (15) inches. In the lower courses, stones shall have minimum volumes of one (1) cubic foot.

951-2.2 POROUS MATERIAL FOR TREE-ROOT PROTECTION. If required, the material for root protection shall be broken stone or washed gravel ranging from $\frac{1}{2}$ to 2 inches in size. Material to be placed above this course to choke the porous layer shall be sand, straw, or some other suitable material approved by the engineer.

951-2.3 TILE. Tile, if required, shall be first quality, hard-burned; agricultural tile, four (4) inches inside diameter.

CONSTRUCTION METHODS

951-3.1. GENERAL. The area for tree-root protection shall be considered as that over which the branches spread. It shall be cleaned thoroughly of all vegetation. Porous material, when required, shall be spread loosely over the area to the depth specified below. Sufficient care shall be taken that the trees are not scarred or otherwise damaged by construction operations.

951-3.2 TREES ABOVE GRADE LEVEL. Where the existing grade at the base of the tree trunk is above the required finished grade level, the ground from the outer edge of the area of tree-root protection shall be sloped to the surrounding grade level without abrupt change in grade.

951-3.3. TREES BELOW GRADE LEVEL. (a) Where existing grades beneath the spread of the branches are less than eight (8) inches below the finished grade level, the area shall be brought

to grade level with soil similar to that used for surrounding finished grading.

(b) Where existing grades beneath the spread of branches are eight (8) inches or more below the finished grade level, a layer of porous material for tree-root protection as specified above shall be spread over the area to the following depths:

Depth of Required Fill	Depth of Porous Material Layer
8 inches-----	2 inches
9 inches-----	3 inches
10 inches-----	4 inches
11 inches-----	5 inches
12 inches or more-----	6 inches

This layer of porous aggregate shall then be covered with a layer of sand or straw to a depth of about one (1) inch to form a compact mat over it. At the outer ring or edge and above the porous aggregate layer, four (4) inch agricultural tile, as specified above, shall be placed in upright positions, approximately eight (8) feet apart, extending from the aggregate layer to the finished grade level. Tile shall be filled with coarse sand to permit the passage of air to the root system. Materials for filling to the finished grade level shall be in accordance with those specified for adjacent areas.

951-3.4 TREE WELLS. Tree wells of dry rubble masonry shall be constructed in accordance with the location dimensions and arrangements shown on the plan, or as directed by the engineer.

METHOD OF MEASUREMENT

951-4.1 The yardage of porous material for tree-root protection to be paid for shall be the number of cubic yards of approved porous material placed in tree-root protections, measured in the vehicle at point of delivery, and accepted.

951-4.2 The yardage dry rubble masonry to be paid for shall be the number of cubic yards complete in place and accepted. Projections extending beyond the faces of walls shall not be included. In computing the yardage for payment, the dimensions used shall be those shown on the plans or ordered in writing by the engineer. No deductions will be made for weep holes, drain pipe, or other openings of less than two (2) square feet in area.

BASIS OF PAYMENT

951-5.1 The yardage of porous material for tree-root protection, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Porous Material for Tree-Root Protection," which price and payment shall constitute full compensation for cleaning the ground surface; for placing the porous fill; for procuring and deliver-

ing all materials; and for all labor, equipment, tools, and incidentals necessary to complete the item, except masonry in tree wells and soil fill.

951-5.2 The yardage of masonry in tree wells, determined as provided above, shall be paid for at the contract unit price per cubic yard for "Dry Rubble Masonry," which price and payment shall be full compensation for furnishing and placing all material; and for all labor, equipment, tools, and incidentals necessary to complete the item.

951-5.3 Subsoil, topsoil, and other materials not included above but which are used in bringing the area to finished grade shall be considered as part of the grading operations for adjacent areas, and payment therefor shall be included in that item.

Payment will be made under:

Item T-951-5.1 Porous Material for Tree Root Protection—per cubic yard.

Item T-951-5.2 Dry Rubble Masonry—per cubic yard.

DIVISION V—LIGHTING INSTALLATION

ITEM L-101 INSTALLATION OF AIRPORT 36-INCH ROTATING BEACON

DESCRIPTION

101-1.1 This item shall consist of an airport 36-inch rotating beacon, furnished and installed in accordance with this specification at the location, and in conformity with the design and dimensions shown on the plans. This work shall include the mounting, leveling, servicing, wiring, painting, and testing of the beacon and all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the engineer. This item shall include a mounting platform, if stipulated on the plans.

MATERIALS

101-2.1 BEACON. The airport rotating beacon shall conform to Specification CAA-291, "Specification for Beacons, 36-inch Double-end Type," with clear and green lenses, except less code flashing mechanism unless specified otherwise. Where specified, the code flashing mechanism shall consist of a contactor and cam cut to flash the code signal assigned to the airport.

When contractor's bid is based on an approved unit, factory inspection, sample unit and serial number requirements are waived.

When contractor's bid is based on a 36-inch rotating beacon not previously approved, the factory inspection and tests and sample unit requirements described in Specification CAA-291 shall not be waived.

101-2.2 PANEL BOARDS AND BREAKERS. Panel boards and breakers shall conform to the requirements of Federal Specification W-P-131, Class 1.

101-2.3 WEATHERPROOF CABINETS. The weatherproof cabinets shall conform to National Electric Manufacturers Standards, and shall be constructed of steel not thinner than No. 16 U. S. S. gauge.

101-2.4 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage shown on the plans or proposal.

101-2.5 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

101-2.6 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand designation. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type 1.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint, conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) International-Orange paint for body and finish coats on metal and wood surfaces shall consist of a ready-mixed, bright, nonfading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of the Federal Specification TT-P-59, Type B.

(d) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) Priming paint for wood surfaces shall be mixed on the job by thinning the above specified International-Orange or white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

CONSTRUCTION METHODS

101-3.1 PLACING THE BEACON. The beacon shall be mounted on a beacon tower, platform, or building roof as shown on the plans.

101-3.2 HOISTING AND MOUNTING. The beacon shall be hoisted to the mounting platform by using suitable slings and substantial hoisting tackle. Before fastening the beacon to the mounting platform, the mounting holes shall be checked for correct spacing. Beacon base or mounting legs shall not be strained or forced out of position to fit incorrect spacing of mounting holes. The beacon base shall be raised first, set in position, and bolted in place. The drum shall then be raised and assembled to the base.

101-3.3 LEVELING. After the beacon has been mounted in place it shall be accurately leveled. The leveling shall be checked in the presence of the engineer, and shall be to the latter's satisfaction.

101-3.4 SERVICING. Before placing the beacon in operation the contractor shall accomplish the following:

- a. Clean and polish all glassware, both inside and outside, using a type of cleanser which will not scratch the lens, and clean the interior of beacon.

- b. Clean interior of beacon base and check for alignment of parts.
- c. Clean and polish slip rings. Apply a very small amount of vaseline to the slip rings, operate about one-half ($\frac{1}{2}$) hour, then wipe surplus off rings. Remove the brushes and lubricate the chamber of the brush holders.
- d. Grease gears of rotating mechanism where gears are accessible. Check to see if gears mesh properly, and turn motor shaft by hand to ascertain if action of gear train is free. Check and adjust the clutch tension. The clutch should be not quite tight enough to stall the motor when the lamp rotating element is held fast. Alemite fittings shall be filled with grease conforming to the manufacturer's or engineer's recommendations.
- e. Set brushes for free motion on slip rings, and adjust springs to one (1) or two (2) pounds pressure to provide firm contact.
- f. Lamps, if available, shall be properly secured in the sockets.

101-3.5 ADJUSTMENT OF BEAM. After the beacon has been mounted and leveled, the elevation of the beams shall be adjusted. The final beam adjustments shall be made at night so that results can be readily observed. The beams shall be adjusted to the elevation directed by the engineer, or as shown on the plans, except that in no case shall the elevation of the beams be less than two (2) degrees above the horizontal.

101-3.6 BEACON MOUNTING PLATFORM. Where the beacon is to be mounted at a location other than the beacon tower and where a special mounting platform is required, the construction of this mounting platform and any necessary lightning protection equipment shall be in accordance with the details shown on the plans.

101-3.7 WIRING. The contractor shall furnish all necessary labor and materials, and shall make complete above-ground electrical connections in accordance with the wiring diagram furnished with the project plans.

If underground cable for the power feed from the transformer vault to the beacon site and duct for this cable installation under paved areas is required, the cable and duct shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable," and Item L-110, "Installation of Underground Duct."

The contractor shall connect the tell-tale relay mechanism in the beacon to light the tower obstruction lights upon failure of the beacon service (primary) lamp.

101-3.8 PANEL AND CABINET. Unless specified otherwise, the contractor shall furnish and install at the top of the beacon tower or mounting platform a circuit-breaker panel consisting of four (4) 15-ampere breakers mounted in a weatherproof cabinet to provide separate protection for the circuits to the beacon lamps, motor, obstruction lights, and other equipment. The cabinet shall be located on the side of the beacon platform, as directed by the engineer.

101-3.9 CONDUIT. All exposed wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. No conduit shall be laid on top of a beacon platform floor. If mounted on steel beacon tower, the conduit enclosing the beacon wiring shall be fastened to the tower members with "Wraplock" straps, clamps, or approved fasteners, spaced approximately five (5) feet apart. Conduit shall be attached to wooden structures with galvanized pipe straps and fastened with galvanized wood screws not smaller than No. 8 or less than 1¼ inches long. There shall be at least two fastenings to each 10-foot length.

101-3.10 BOOSTER TRANSFORMER. When specified, a booster transformer to compensate for voltage drop to the beacon shall be installed in a suitable weatherproof housing under or on the tower platform, or shall be installed at the base of the tower, as indicated on the plans and described in the proposal. If this booster transformer is required for installation in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

101-3.11 PAINTING. If construction of a wooden mounting platform is stipulated in the proposal as part of this item, all wooden parts of the platform shall be given one priming coat of white or International-Orange paint after fabrication but before erection, and one body and one finish coat of International-Orange paint after erection. Steel mounting platforms shall be given one priming coat of red lead before erection, and one body and one finish coat of International-Orange paint after erection. All equipment installed under this contract and exposed to the weather shall be given one body and one finish coat of International-Orange paint. This shall include beacon (except glass surfaces), beacon base, breaker cabinet, all conduit and transformer cases. It shall not include lightning rods nor obstruction light globes.

The paint shall be applied uniformly in the proper consistency by skilled painters. The finished paint shall be free from sags, holidays, smears, and colors, other than those specified. If the wrong color is spilled or applied to a surface, it shall be removed without damage to the surface from which removed. Each coat of paint shall be given ample time to dry and harden before the next coat of paint is applied. A minimum of three (3) days shall be allowed for drying on wood surfaces and a minimum of four (4) days shall be allowed for drying on metal surfaces. No painting shall be done in cold, damp, foggy, dusty, or frosty atmospheres, or when air temperature is below 40° F., or started when the weather forecast indicates such conditions for the day.

All surfaces shall be prepared for painting by cleaning. The surfaces shall be dry and free from scale, grease, rust, dust, and dirt when paint is applied. All knots in wood surfaces shall be killed with shellac immediately before applying the priming coat of paint. Nail holes and permissible imperfections shall be filled with putty.

The ready-mixed paint shall be thinned for the priming and body coats in accordance with the manufacturer's recommendations. In the absence of such recommendations, the following shall apply:

Body Coats (for both wood and steel surfaces)—Add one-half ($\frac{1}{2}$) pint of turpentine to each gallon of ready-mixed paint for body coats.

Finish Coats (for both wood and steel surfaces)—The ready-mixed paint shall be used as it comes from the container for finish coats.

101-3.12 TESTING. The installation shall be fully tested in operation as a completed unit prior to acceptance, and these tests shall include lamp-changer operation, megger and voltage readings. The resistance to ground of the beacon supply circuit shall be not less than 100,000 ohms. Testing equipment shall be furnished by the contractor. Tests shall be conducted in the presence of the engineer, and shall be to his satisfaction.

METHOD OF MEASUREMENT

101-4.1 The quantity to be paid for under this item shall be the number of beacons installed as completed units in place, ready for operation, and accepted.

BASIS OF PAYMENT

101-5.1 Payment shall be at the contract unit price for each complete job with all necessary materials furnished in place by the contractor and accepted by the engineer, which price and payment shall constitute full compensation for the furnishing, mounting, leveling, servicing, and adjusting of the beacon (less code flashing mechanism unless specified otherwise); for furnishing and installing the breaker panel and weatherproof cabinet, unless otherwise specified; for connecting the tell-tale relay to the obstruction lights; for furnishing and installing all electrical connections, including wiring, conduit, and fittings; for painting all material installed under this item; for furnishing and installing a booster transformer, if specified; for furnishing, fabricating, and erecting a beacon mounting platform, if specified; and for all labor, equipment, tools, tests, and testing equipment necessary to complete this item.

Payment will be made under:

Item L-101-5.1 Airport 36-inch Rotating Beacon, in Place—per unit.

ITEM L-102 INSTALLATION OF AIRPORT CODE BEACON

DESCRIPTION

102-1.1 This item shall consist of an airport code flashing beacon, furnished and installed in accordance with this specification at the location, and in conformity with the design and dimensions shown on the plans. This work shall include the mounting, leveling, wiring, servicing, painting, and testing of the code beacon and all materials and incidentals necessary to place it in operating condition as a completed unit, to the satisfaction of the engineer. This item shall include a mounting platform, if stipulated on the plans.

MATERIALS

102-2.1 BEACON. The airport code beacon shall conform to Specification CAA-446, "Specification for Code Beacons," Style III, with green color filters.

When contractor's bid is based on an approved unit, factory inspection and sample unit requirements are waived.

When contractor's bid is based on an airport code beacon not previously approved, the factory inspection and tests and sample unit requirements described in Specification CAA-446 shall not be waived.

102-2.2 PANEL BOARDS AND BREAKERS. Panel boards and breakers shall conform to the requirements of Federal Specification W-P-131, Class I.

102-2.3 WEATHERPROOF CABINETS. Weatherproof cabinets shall conform to National Electric Manufacturers Standards, and shall be steel not thinner than No. 16 U. S. S. gauge.

102-2.4 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage shown on the plans or proposal.

102-2.5 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

102-2.6 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand designation. The raw linseed oil, turpentine, and drier shall be in accordance with Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type I.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) International-Orange paint for body and finish coats on metal and wood surfaces shall consist of a ready-mixed, bright, nonfading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of Federal Specification TT-P-59, Type B.

(d) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified International-Orange or white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

102-2.7 FLASHER. The flasher mechanism shall be similar and equal to Crouse-Hinds Type TSS-18 or Westinghouse Style 891510, with cam cut to flash the code signal _____.

CONSTRUCTION METHODS

102-3.1 PLACING THE BEACON. The code beacon shall be mounted on a beacon tower, platform, or building roof, as shown on the plans.

102-3.2 MOUNTING AND LEVELING. The support to which the code beacon is fastened shall be accurately leveled before mounting the beacon.

102-3.3 FLASHER. If specified on the proposal, a separate flashing mechanism for the code beacon shall be installed adjacent to the code beacon and on the same mounting platform. The rotating cam in this flasher shall be cut to flash the code signal assigned to the airport.

102-3.4 MOUNTING PLATFORM. If specified in the proposal, the contractor shall construct a special mounting platform for the beacon, code flasher, and incidental equipment. Design and materials for the special platform shall be as shown on the plans.

If specified in the proposal, the code beacon shall be mounted on a standard steel beacon tower. If this tower supports an existing rotating beacon, an auxiliary platform shall be supplied, as described on the plans.

102-3.5 WIRING. The contractor shall furnish all necessary labor and materials, and shall make complete above-ground electrical connections in accordance with the wiring diagram furnished with the project plans.

If underground cable for the power feed from the transformer vault to the beacon site and duct for the installation of this cable under paved areas is required, the cable and duct shall be installed in accordance with (and paid for by linear foot measurement as described in)

Item L-108, "Installation of Underground Cable," and Item L-110, "Installation of Underground Duct."

102-3.6 PANEL AND CABINET. If specified, the contractor shall furnish and install a circuit-breaker panel consisting of four (4) 15-ampere breakers mounted in a weatherproof cabinet. The cabinet shall be located on the side of the platform, as directed by the engineer.

102-3.7 CONDUIT. All exposed wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. No conduit shall be laid on top of a beacon platform floor. If mounted on a steel beacon tower, the conduit shall be fastened to the tower members with "Wraplock" straps, clamps, or approved fasteners, spaced approximately five (5) feet apart.

102-3.8 BOOSTER TRANSFORMER. When specified, a booster transformer to compensate for voltage drop to the beacon shall be installed in a suitable weatherproof housing under or on the tower platform, or shall be installed at the base of the tower, as indicated on the plans and described in the proposal.

If this booster transformer is required for installation in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

102-3.9 PAINTING. If construction of a mounting platform is stipulated in the proposal as part of this item, all wooden parts of the mounting platform shall be given one priming coat of white or International-Orange paint after fabrication but before erection, and one body and one finish coat of International-Orange paint after erection. Steel mounting platforms shall be given one priming coat of red lead before erection, and one body and one finish coat of International-Orange paint after erection. All equipment installed under this contract and exposed to the weather shall be given one body and one finish coat of International-Orange paint. This shall include beacon (except glass surfaces), breaker cabinet, all conduit and transformer cases. It shall not include lightning rods nor obstruction light globes.

The paint shall be applied uniformly in the proper consistency by skilled painters. The finished paint shall be free from sags, holidays, smears, and colors, other than those specified. If the wrong color is spilled or applied to a surface, it shall be removed without damage to the surface from which removed. Each coat of paint shall be given ample time to dry and harden before the next coat of paint is applied. A minimum of three (3) days shall be allowed for drying on wood surfaces and a minimum of four (4) days shall be allowed for drying on metal surfaces. No painting shall be done in cold, damp, foggy, dusty, or frosty atmospheres, or when air temperature is below 40° F., or started when the weather forecast indicates such conditions for the day.

All surfaces shall be prepared for painting by cleaning. The surfaces shall be dry and free from scale, grease, rust, dust, and dirt when paint is applied. All knots in wood surfaces shall be killed with shellac immediately before applying the priming coat of paint. Nail holes and permissible imperfections shall be filled with putty.

The ready-mixed paint shall be thinned for the priming and body coats, in accordance with the manufacturer's recommendations. In the absence of such recommendations, the following shall apply:

Body Coats (for both wood and steel surfaces)—Add one-half ($\frac{1}{2}$) pint of the turpentine to each gallon of ready-mixed paint for body coats.

Finish Coats (for both wood and steel surfaces)—The ready-mixed paint shall be used as it comes from the container for finish coats.

102-3.10 TESTING. The installation shall be tested in operation as a completed unit prior to acceptance. Tests shall include megger and voltage readings. Testing equipment shall be furnished by the contractor. The resistance to ground of the code beacon supply circuit shall not be less than 100,000 ohms. Tests shall be conducted in the presence of the engineer and shall be to his satisfaction.

METHOD OF MEASUREMENT

102-4.1 The quantity to be paid for under this item shall be the number of code beacons installed as completed units in place, accepted, and ready for operation.

BASIS OF PAYMENT

102-5.1 Payment shall be at the contract unit price for each complete job, with all necessary materials furnished in place by the contractor and accepted by the engineer, which price and payment shall constitute full compensation for the furnishing, mounting, and leveling of the code beacon; for the furnishing and installing of all electrical connections, including wiring, conduit, and fittings; for the painting of all material installed under this item; for the furnishing and installing of the breaker panel and weatherproof cabinet, mounting platform, flasher, and/or booster transformer, as specified; and for all labor, equipment, tools, tests, and testing equipment necessary to complete this item.

Payment will be made under:

Item L-102-5.1 Airport Code Beacon, in Place—per unit.

ITEM L-103 INSTALLATION OF AIRPORT BEACON TOWERS

DESCRIPTION

103-1.1 This item shall consist of an airport beacon tower of the type specified or shown on the plans, furnished and installed in accordance with this specification at the location, and in conformity with the design and dimensions shown on the plans. The work shall include the clearing of the site, erection of the tower, installation of lightning protection, painting, and all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the engineer.

MATERIALS

103-2.1 TOWER. The steel beacon tower shall conform to Specification AN-T-11, "Tower; Aerial Navigation Beacon," of the height¹ specified on the proposal, less wind cone bracket, unless specified otherwise.

The requirements of AN-T-11, covering factory inspection, sample tower, and reproducible copies of instruction book, are waived. The waiver of these requirements does not relieve the contractor's obligations to meet the other requirements of this specification.

103-2.2 LIGHTNING ROD. The lightning rod shall consist of a galvanized steel or solid copper rod or bar with the upper end drawn to a point and of sufficient length to extend from the point of fastening to six (6) inches above the topmost part of the beacon.

103-2.3 CABLE. The down conductor cable for lightning protection shall consist of No. 2/0 B. S. gauge bare stranded copper wire or larger.

103-2.4 GROUND ROD. The ground rod shall be a standard 5/8-inch diameter six (6) feet long, copper or copper-clad ground rod.

103-2.5 GROUND CLAMP. Ground clamp shall be similar and equal to the Type GR as manufactured by the Burndy Engineering Company.

103-2.6 PAINT. (a) Priming paint for galvanized steel towers shall be zinc dust-zinc oxide primer paint conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half (1/2) pint of turpentine to the gallon.

(b) Priming paint for steel towers, not galvanized, shall be red lead, and the mixing thereof shall conform to the 95-percent grade

¹ Heights of 51, 62, 75, 91, 108, 129, and 152 feet are standard.

Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type I.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(c) International-Orange paint for steel towers shall consist of a ready-mixed, bright, nonfading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of Federal Specification TT-P-59, Type B.

(d) White paint for steel tower shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

CONSTRUCTION METHODS

103-3.1 CLEARING AND GRADING. The site on which the beacon tower is to be erected shall be properly cleared and leveled. All trees and brush shall be removed from the area within a distance of twenty-five (25) feet from the tower or as called for on the job plans. Stumps shall be removed to a depth of eighteen (18) inches below finished grade, and the excavation filled with earth and tamped. If a transformer vault or other structure is included as part of the installation, the area shall be cleared to a distance of twenty-five (25) feet from any of the structures. The ground near the tower shall be leveled sufficiently to permit the operation of mowing machines. The leveling shall extend at least two (2) feet outside the tower legs. All debris removed from the tower site shall be disposed of by the contractor to the satisfaction of the engineer, and in accordance with Federal, State, or local regulations.

103-3.2 EXCAVATION AND FILL. Excavation for the tower footings shall be carried to a minimum of four (4) inches below the footing depth. The excess excavation below the footing depth shall then be backfilled with gravel or crushed stone and compacted to the required level. The footing plates shall be installed, and not less than eighteen (18) inches depth of the same gravel or crushed stone shall be placed immediately above the footing plates in layers of not over four (4) inches. Each layer below and above the footing plates shall be thoroughly tamped in place. The remainder of the backfill may be of excavated earth, placed in not to exceed six (6) inch layers. Each layer shall be thoroughly compacted by tamping.

Where solid rock is encountered, preventing the carrying of the foundation legs to the required depth but of sufficient strength that hold-down bolts can be used, and their use is approved by the engineer, the tower anchor posts shall be cut off at the required length,

and hold-down bolts shall be installed as indicated in the plans. Each tower leg shall be anchored to the rock by means of two (2) $\frac{7}{8}$ -inch diameter by 3-foot-long expansion or split bolts, and shall be grouted with neat Portland cement into holes drilled into the natural rock. Except as required for rock foundations, the footing members shall not be cut off or shortened without orders from the engineer in writing. If excavated material is of such character that it will not closely compact when backfilled, the engineer may order the excavation backfilled with concrete.

Any changes in the above provisions that may be necessary, due to unusual soil conditions, etc., shall be subject to the approval of the engineer before installation is made.

103-3.3 ERECTION. Detail erection drawings furnished by the manufacturer shall be strictly followed during construction. All towers shall be erected piece by piece from the ground up. In final assembly, all bolts and fastenings shall be installed, and the structure shall be plumb, true, square, and level. Nuts shall be taken up to a firm bearing after which the bolts shall, if necessary, be cut to proper length to protrude three full threads. Approved locknuts shall be placed on each bolt over the regular nut. Ladder bolts shall be inserted with the head to the outer face of the tower. Diagonal, leg, and hand-rail bolts shall be installed with nuts on the outer face of the tower, unless otherwise specified. Bent parts shall be straightened before erection without damage to the protective coating. Surfaces abraded or bared of protective coating shall be painted with the proper priming paint, as specified in these specifications.

The contractor shall install the ladder on the side of the tower adjacent to the driveway or most accessible approach to the tower. Where called for on the plans, oversize footing plates shall be installed.

103-3.4 LIGHTNING PROTECTION. Unless otherwise specified, the contractor shall furnish and install a lightning rod, down conductor, and at least one ground plate or rod for each beacon tower. The lightning rod shall be installed at the top of the tower with the tip of the rod extending approximately six (6) inches above the topmost part of the beacon.

Down-conductor cables shall be securely fastened to the surface or tower leg every five (5) feet with suitable bronze fasteners having bronze or noncorrodible metal bolts. Sharp turns or bends in the down-conductor shall be avoided.

All connections of cable to cable, cable to lightning rods, and cable to ground plates or rods shall be made with approved type solderless connectors of noncorrosive metal and of substantial construction.

The down-conductor cable shall be securely attached to the ground rods or plates placed at least two (2) feet away from the tower foundations.

The ground rod shall be driven into the ground to a depth of at least four (4) feet. The down-conductor cable shall be firmly attached to the ground rod or plate by means of a ground connector or clamp. Plates shall be imbedded below permanent moisture level, unless otherwise specified.

The complete lightning protection installation shall be done in a neat and workmanlike manner, to the satisfaction of the engineer. The resistance to ground of any part of the lightning protection system shall not exceed twenty-five (25) ohms.

103-3.5 PAINTING. The contractor shall furnish all materials and labor for painting the beacon tower. The color scheme for the steel tower shall be as shown on the plans.

Parts to be painted: Tower parts (except those parts to be exposed to earth) shall not be treated or primed before erection. All tower parts placed below ground level, or within twelve (12) inches above ground level shall be given two coats of approved bituminous paint.

The paint shall be applied uniformly in the proper consistency by skilled painters. The finished paint shall be free from sags, holidays, smears, and colors other than those specified. When wrong color is spilled or applied to a surface, it shall be removed without damage to the surface from which removed. Division lines between colors shall be sharply defined. Each coat of paint shall be given ample time to dry and harden before the next coat is applied. A minimum of three (3) days shall be allowed for drying on wood surfaces, and a minimum of four (4) days shall be allowed for drying on metal surfaces. No painting shall be done in cold, damp, foggy, dusty, or frosty atmospheres, or when air temperature is below 40° F., or started when the weather forecast indicates such conditions for the day.

All surfaces shall be prepared for painting by cleaning. The surfaces shall be dry and free from scale, grease, dust, rust, and dirt when paint is applied. All galvanized iron and steel surfaces of steel towers, including the wind cone bracket if used, shall be given one priming coat of zinc-dust-zinc-oxide primer in place of red lead priming on galvanized metal surfaces.

The number of coats of paint applied shall be in accordance with the following instructions:

Steel Towers, Galvanized—One priming coat of zinc dust-zinc oxide primer after erection, and one body and one finish coat of white or International-Orange paint (as required by the color scheme) applied after erection.

Steel Towers, not Galvanized—One priming coat of red lead priming paint, and one body and one finish coat of white or International-Orange paint (as required by the color scheme) applied after erection.

The above-specified International-Orange and white ready-mixed paints shall be thinned for the body coats in accordance with the manufacturer's recommendations. In the absence of such recommendations, the following shall apply:

Body Coats—Add one-half ($\frac{1}{2}$) pint of turpentine to each gallon of ready-mixed paint for body coats.

Finish Coats—The ready-mixed paint shall be used as it comes from the container for finish coats.

METHOD OF MEASUREMENT

103-4.1 The quantity to be paid for under this item shall be the number of airport beacon towers installed as completed units in place, accepted, and ready for operation.

BASIS OF PAYMENT

103-5.1 Payment shall be at the contract unit price for each complete job with all necessary materials furnished, in place by the contractor, and accepted by the engineer; which price and payment shall constitute full compensation for clearing and grading; for furnishing, erecting, painting, and treating the beacon tower (less wind cone bracket unless specified otherwise), including excavating and filling; for furnishing and installing lightning protection; for furnishing and installing oversize footing plates, if specified; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-103-5.1 Airport Beacon Tower, in Place—per unit.

ITEM L-104 INSTALLATION OF AIRPORT FLUSH MARKER LIGHTS

DESCRIPTION

104-1.1 This item shall consist of flush marker lights, including contact lights, flush range lights, flush boundary lights, taxi lights, and other flush marker lights, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installation of concrete pads or handholes for mounting the light units, if specified, and the furnishing and installation of conduit lead-ins and grounding conductors, if required.

The item shall also include all cable connections, the furnishing and installation of all lamps and film cutouts, the testing of the installation, and all incidentals necessary to place these lights in operation as a completed unit, to the satisfaction of the engineer.

MATERIALS

104-2.1 FLUSH MARKER LIGHTS. Flush marker lights shall conform to Specification AN-L-9, "Army-Navy Aeronautical Specification—Lamp Assembly; Runway Marker," in the quantity specified in the proposal; each unit to be complete with top assembly of the type and class specified in the proposal, with the color filters specified in the proposal and with a type AN-2512-12 shallow base assembly complete with bolts, gasket, and plywood cover, unless specified otherwise. Where specified, the base assembly shall consist of type AN-2512-2 deep base assembly complete with bolts, gasket, and plywood cover.

The combat hood is not required.

When contractor's bid is based on an approved unit, qualification, production sample, and inspection test requirements are waived.

When contractor's bid is based on flush marker lights not previously approved, described in Specification AN-L-9, shall not be waived. approved, the factory inspection and tests and sample unit requirements, described in Specification AN-L-9, shall not be waived.

104-2.2 CONCRETE. The concrete for pads or manholes shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

104-2.3 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed bars, and shall meet

the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

104-2.4 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

104-2.5 SQUEEZE CONNECTORS. Squeeze connectors shall be similar and equal to Crouse-Hinds Type CGB cable connector with neoprene rubber bushing of maximum durometer hardness of 40.

104-2.6 TEES. Large radius bend tees shall be similar and equal to Crouse-Hinds No. ET43.

104-2.7 GROUND ROD. The ground rod shall be standard $\frac{5}{8}$ -inch diameter, 6 feet long, copper or copper-clad ground rod.

104-2.8 CABLE FOR GROUNDING. The ground conductor cable shall be No. 8 B & S gauge bare stranded copper wire.

104-2.9 GROUND CLAMPS. Ground clamps shall be similar and equal to Types GR as manufactured by the Burndy Engineering Company.

CONSTRUCTION METHODS

104-3.1 PLACING THE LIGHTS. The flush marker lights shall be installed at the approximate location indicated on the plans. The exact location shall be as directed by the engineer.

104-3.2 LEVELING. The marker light base shall be adjusted and firmly held in place so that the machined upper surface of the base flange will extend $\frac{1}{4}$ inch above the surface of the concrete pad. The base flange shall be level within plus or minus one (1) degree.

104-3.3 FLAG HOLDER. If stipulated on the plans, the contractor shall install a $\frac{3}{4}$ -inch galvanized pipe sleeve, at least six (6) inches long, vertically in the concrete pad on the runway side of the marker light to hold the staff of a warning flag for warning snow plows and mowing machines away from the light unit. A $\frac{3}{4}$ -inch galvanized coupling and plug shall be installed at the top of the sleeve. The top of the coupling shall be flush with the surface of the concrete pad.

104-3.4 CONCRETE PAD. The flush marker lights shall be installed in concrete pads, approximately three (3) feet square, located inside the edge of the pavement. The concrete pad shall not be prefabricated but shall be poured in place and shall rest on undisturbed soil. It shall be reinforced with steel bars formed and placed as indicated on the plans. The exposed concrete surface shall be finished smooth with a steel trowel or rubbed to a smooth finish. The pad shall be sloped to the same direction and grade as the runway to provide proper drainage. After the concrete has set sufficiently, the contractor shall remove the construction support and forms, clean out any debris which may be in the base, and install the plywood cover. The contractor shall install the top assembly after wiring, and as described hereafter.

104-3.5 KEYING. If the pad is installed in a concrete runway pavement, the pad shall be keyed to the runway on three sides, as indicated on the plans, and the key joints sealed with the same material and in the same manner as for the joints in the concrete runways. If

the pad is installed in a flexible runway pavement, keying shall not be required but joints shall be sealed with asphalt material of from 85 to 150 penetration.

104-3.6 IDENTIFICATION NUMBER. Where it is specified that the flush light is to be installed in a concrete pad with or without handholes, the contractor shall impress an identifying number on the top surface of the side nearest and parallel to the runway center line. The number shall be approximately 4 inches high, 3 inches wide and $\frac{1}{2}$ -inch stroke. The numbers shall correspond with the numbers indicated on the lighting plan, or as designated by the engineer.

104-3.7 INSTALLATION IN HANDHOLES. Where the plans require the light unit to be installed with a handhole, the provisions of the preceding paragraphs shall be observed, except that the concrete structure shall conform to the design and dimensions indicated on the plans.

104-3.8 GROUNDING. A unit installed with a handhole shall be grounded to a 6-foot long, $\frac{5}{8}$ -inch diameter copper or copper-clad ground rod by a short length of No. 8 B & S gauge bare stranded copper wire. Connections shall be made, and the grounding wire run in a manner indicated on the plans. The resistance to ground shall not exceed 25 ohms. The identifying number described in paragraph 3.6 shall be impressed on the handhole cover.

104-3.9 CABLE ENTRANCE. Cable will be installed between the flush marker light units as a separate item, and the contractor shall bring this cable into the flush marker lights, as shown on the plans. The cable entrance to the unit (or to conduit to tee leading into the unit) shall be sealed by squeeze connectors, unless otherwise indicated on the plans. Galvanized steel conduit reducers, shall be used where required. The cable connectors shall be provided with a rubber bushing, correctly sized to fit the outside diameter of the cable. The connectors shall be tightened sufficiently to provide a watertight seal without deforming the insulation and sheath of the cable.

104-3.10 CABLE CONNECTIONS. In making cable connections to the AN-L-9 type flush lights, the contractor shall pull cables into each light base, and shall leave sufficient slack cable inside the base to permit connections to be made to the lamp receptacle binding posts when the whole head assembly is removed from the base.

Cable connections shall be made to the lamp sockets of AN-L-9 flush marker light units as follows:

The insulation shall be removed from the conductor ends without nicking the conductor, and the ends of the insulation shall be sealed off. Exposed conductors shall then be connected to the terminals of the flush marker light socket so that each terminal is on the same side as that from which its connecting cable enters. Ends of exposed conductor projecting through the terminals shall be clipped off. To prevent the conductors from bending and breaking at the binding posts, and to eliminate strain on the conductors at this point when

the head assembly is inserted or removed from the base, the socket leads near the terminals shall be bent and trained upward along the outside of the socket-supporting shell, and the cable shall be securely anchored to the shell by an over-all wrapping of friction tape carried completely around the shell. The tape shall be painted with a bituminous paint.

104-3.11 CONDUIT LENGTH. Where contact lights are installed in the runway paving, the conduit shall extend 18 inches from the paving edge, subbase edge, or outer edge of trench for drain, whichever is most distant from pavement centerline.

104-3.12 LIGHT ADJUSTMENT. After installation the contractor shall adjust the asymmetric lens of each contact light, flush range light, or taxi light so that the two concentrated beams of light shine up and down the runway or taxiway, and are "toed-in" symmetrically toward the centerline. The contractor shall be held responsible for correct orientation and adjustment of all asymmetric flush marker lights installed by him. The final adjustment of the asymmetric lenses shall be made at night, after the flush marker light installation is completed, and power turned on for testing. The contractor shall make the final adjustments in the presence of the engineer, and to the latter's satisfaction.

104-3.13 LAMPS. The contractor shall furnish and install in each unit a lamp conforming to the following requirements:

- a. *Series Lamps*—A-21 bulb, $2\frac{3}{4}$ inches LCL, $5\frac{5}{16}$ inches maximum over-all length, medium prefocus base, 325-lumen for use with clear and yellow filters, 1020-lumen for use with green, blue, or red filters.
- b. *Multiple Lamps*—A-21 bulb, $2\frac{3}{4}$ inches LCL, $5\frac{5}{16}$ inches maximum over-all length, medium prefocus base, 40-watt, for use with clear and yellow filters, 100-watt for use with green, blue, or red filters.

METHOD OF MEASUREMENT

104-4.1 The quantity of lights to be paid for under this item shall be the number of each type of flush marker lights installed as complete units, in place, ready for operation, and accepted.

BASIS OF PAYMENT

104-5.1 Payment for lights shall be made at the contract unit price for each complete contact light, flush range light, flush boundary light, taxi light, or other flush marker light installed in place and accepted by the engineer; which price and payment shall constitute full compensation for furnishing, leveling, installing, and adjusting all flush marker lights of the type, class, and color specified (complete with shallow bases, unless specified otherwise); for furnishing, installing, keying, or sealing concrete pads; for furnishing,

ITEM L-105 INSTALLATION OF AIRPORT CONE-MOUNTED LIGHTS FOR SERIES CIRCUITS

DESCRIPTION

105-1.1 This item shall consist of cone-mounted lights, including boundary, range, and obstruction lights, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installing of concrete pads for mounting the light units, of conduit lead-ins, and of ground connections, if required.

This item shall also include all cable connections, the furnishing and installing of all lamps and film cutouts, and the testing of the installation, and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

105-2.1 CONE-MOUNTED LIGHTS. The cone-mounted boundary, range, or obstruction lighting units shall conform in all respects to Specification AN-L-10, "Army-Navy Aeronautical Specification—Lamp Assembly; Boundary and Obstruction Marker," in the quantity specified in the proposal; each unit to be complete with globe, fitting, cone, and cone mounting and, if required, filter as specified by AN part number in the proposal. (See Table 1.) The combat hood is not required.

When contractor's bid is based on an approved unit, qualification, production sample and inspection test requirements are waived.

When contractor's bid is based on cone-mounted lights not previously approved, the factory inspection and tests and sample unit requirements described in Specification AN-L-10 shall not be waived.

105-2.2 CONCRETE. The concrete for the bases or pads of the cone-mounted lights shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

105-2.3 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

105-2.4 INSULATING COMPOUND. Insulating compound shall be similar and equal to "Ozite B," as manufactured by the General Cable Corporation.

CONSTRUCTION METHODS

105-3.1 PLACING THE LIGHTS. The cone-mounted lights shall be installed at the approximate locations shown on the plans. The exact location shall be as directed by the engineer.

105-3.2 CONCRETE PAD. The cone-mounted lights shall be installed on individual concrete pads, as shown on the plans. Each pad shall be 5 feet by 5 feet, with a minimum depth of 6 inches at the center and 3 inches at the edges. The pad shall slope toward the edges from the center 1 inch per foot of horizontal surface, and shall have a 1-inch beveled edge at 45 degrees from the vertical. A suitable form, constructed so as to give the pad the proper dimensions and shape, shall be prepared. This form shall be oriented so that two opposite sides will be approximately parallel to the line of cable, or as directed by the engineer. The form should be placed so that the top edge of the perimeter shall be 3 inches above the normal ground line. The concrete pads shall not be prefabricated but shall be poured in place. The exposed surface shall be finished with a steel trowel or rubbed so that it is smooth.

105-3.3 IDENTIFICATION NUMBER. An identifying number shall be impressed on the side nearest the runway of the top surface of each pad. The number shall be approximately 4 inches high, 3 inches wide, with a $\frac{1}{2}$ -inch wide stroke. The number shall correspond with the numbers indicated on the lighting plan.

105-3.4 CABLE ENTRANCE. Underground cable will be installed between the units as a separate item, and the contractor shall bring this cable into the cone-mounted lights. The contractor shall furnish and install rigid steel conduit lead-ins for the cable. The cut-out receptacle, with conduit attached, shall be set in place in the center of the pad form. The conduit assembly shall be oriented so that the conduit will be approximately parallel to the line of cable and parallel to two opposite edges of the pad form. The small flange on the cut-out receptacle shall be level within plus or minus two (2) degrees, and the lower surface of this flange flush with the upper surface of the concrete pad at that point.

105-3.5 BACKFILL AND GRADING. The conduit trenches and other excavation under the pad shall be backfilled and tamped to compaction equal to that of the undisturbed soil. Sufficient earth shall be placed and compacted around the concrete pad to form an inclined slope of approximately 15 degrees between the top edges of pad and the normal ground line.

105-3.6 ANCHOR. Where cone-mounted lights are subjected to propeller blasts from nearby aircraft, and where required on the plans, a suitable anchor shall be installed in the concrete, as shown on the plans.

105-3.7 CABLE CONNECTIONS. When pulling the cable into the conduit and making connections to the receptacle in the pad, at least one (1) foot of slack cable shall be left on each side of the pad where the cable enters the conduit to allow for future ground settlement. When making connections to the boundary light receptacles sufficient insulation and sheath shall be removed from the cable ends to leave the conductors bare from the binding posts to a point at least $\frac{1}{4}$ inch below the surface of the insulating com-

pound. The insulation shall be penciled down to a 2-to-1 taper. After electrical connections are completed, the receptacle casting shall be filled with insulating compound. This compound shall be poured at a temperature which is within the limits recommended by the manufacturer of the compound, and the pouring temperature shall be measured by a thermometer. The receptacle shall be filled to a level sufficient to cover the cable entrance openings but not high enough to spill over into the chamber enclosing the prong clips. The cable entrance hubs shall be stuffed with oakum to keep the compound from running into the conduit. Any compound spilled on the prong clips, or compound which interferes with the normal operation of inserting the plug in the receptacle, shall be removed.

105-3.8 GROUNDING. The cone shall be grounded to the receptacle with a No. 10 AWG stranded copper conductor, if required on the plans.

105-3.9 LIGHT ORIENTATION. Cone lights having two-color globes ($\frac{1}{2}$ yellow, $\frac{1}{2}$ white) shall be oriented so that the division lines between the yellow and white halves are at right angles to the centerline of the landing strip. The white half of the globe shall be pointed toward the approach, or near end of the runway, and the yellow half shall be directed toward the far end.

105-3.10 TESTS. If required in the proposal, the grounding connection and circuit cable connections to each cone-mounted light unit shall be tested for ground resistance and insulation resistance. The testing procedure shall be in accordance with the applicable provisions of Item L-108, "Installation of Airport Underground Cable," or as directed by the engineer. The contractor shall also test the anchoring of the cones to the pads where anchoring is provided.

105-3.11 LAMP AND CUT-OUT. The contractor shall furnish and install in each unit a film cut-out of the proper size and a series lamp conforming to the following requirements:

A-21 bulb, $2\frac{3}{4}$ inches LCL, $5\frac{5}{16}$ inches maximum over-all length; medium prefocus base, 320-lumen for use with clear or yellow globes, 1020-lumen for use with green or red globes.

METHOD OF MEASUREMENT

105-4.1 The quantity of lights to be paid for under this item shall be the number of each type of cone-mounted lights installed as completed units in place, ready for operation, and accepted.

BASIS OF PAYMENT

105-5.1 Payment for lights shall be made at the contract unit price for each complete cone-mounted boundary, range, or obstruction light installed in place, and accepted by the engineer; which price and payment shall constitute full compensation for furnishing and installing the cone-mounted light; for furnishing and installing

the concrete pad; for furnishing and installing the cut-out receptacle in the pad; for impressing identifying numbers on the concrete pad; for furnishing and installing rigid steel conduit lead-ins and any necessary fittings for the cable entrance; for furnishing and installing a means for anchoring the cone, if specified; for orienting the two-color globes, if required; for furnishing and installing a grounding connection, if specified; for furnishing and installing the lamp and film cut-out; for making all cable connections; for furnishing and pouring sealing compound; for adjusting and testing and furnishing all testing equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-105-5.1 Airport Cone-Mounted Lights, in Place—per unit.

TABLE 1.—Cone-Mounted Lights

Series	Globe	Cone	Fitting	Cone mounting	Filter
Clear Series Boundary Light, complete with	{AN-2541-1 prismatic. or AN-2541-11 fresnel. AN-2541-3 prismatic.	{2542-1 orange	2547-1	2543-1	{None. None. None.
Green Series Range Light, complete with	{AN-2541-13 fresnel. or AN-2541-6 prismatic.	{2542-2 orange and white	2747-1	2543-1	{None. None. None.
½ Clear, ½ Yellow Series Boundary Light, complete with.	{AN-2541-16 fresnel. or AN-2541-4 prismatic.	{2542-1 orange	2747-1	2543-1	{None. None. 2545-4 yellow.
Yellow Auxiliary Series Range Light, complete with.	{AN-2541-14 fresnel. or AN-2541-2 prismatic.	{2542-2 orange and white	2747-1	2543-1	{None. None. None.
Red Series Boundary Obstruction Light, complete with.	{AN-2541-12 fresnel.	{2542-1 orange	2747-1	2543-1	{None. None.

ITEM L-106 INSTALLATION OF AIRPORT OBSTRUCTION LIGHTS

DESCRIPTION

106-1.1 This item shall consist of single and double obstruction lights, including series and multiple circuit types, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installation of wood poles, steel or iron pipes, or other supports, if stipulated on the plans or in the job specifications.

This item shall also include all wire and cable connections, the furnishing and installation of all necessary conduit and fittings, insulators, pole steps, pole cross arms, disconnecting hangers, and the painting of poles and pipes, the furnishing and installing of all lamps and, if required, film cut-outs; the furnishing and installing of isolating transformers, if specified; and the servicing and testing of the installation and all incidentals necessary to place these lights in operation as a completed unit, to the satisfaction of the engineer.

MATERIALS

106-2.1 OBSTRUCTION LIGHTS. The obstruction lights shall conform to both or either of the following, as required and as stipulated in the proposal:

- a.* Specification AN-L-10, "Army-Navy Aeronautical Specification—Lamp Assembly, Boundary and Obstruction Marker," in the quantity specified in the proposal; each unit to be complete with globe(s) and fitting, as specified by AN part number in the proposal. (See Table 1.) The combat hood is not required.
- b.* Specification AN-L-31, "Army-Navy Aeronautical Specification—Lamp Assembly, Disconnecting Obstruction Marker," in the quantity specified in the proposal; each unit consisting of the following parts:
 - (1) Obstruction Light Disconnecting Fitting Assembly consisting of two AN-2541-2 prismatic or AN-2541-12 fresnel globes, two AN-2547-5 top sections, and one AN-2548-2 base.
 - (2) Disconnecting Hangar Assembly with adapter, cables, and all fittings necessary for the completed installation and:
 - a.* With accessories for use up to 100-foot mounting height, or

- b. With accessories for use up to 200-foot mounting height.
- c. Complete with winch assembly,¹ as specified in the proposal.

When contractor's bid is based on airport obstruction lights not previously approved, the factory inspection and tests and sample unit requirements described in Specification AN-L-10 shall not be waived.

When contractor's bid is based on an approved unit, qualification, production sample, and inspection test requirements are waived.

106-2.2 CONDUIT. (a) Fiber conduit and fittings shall be in accordance with the Federal Specification W-C-581.

(b) Steel conduit and fittings shall be in accordance with Federal Specification WW-C-581.

106-2.3 POLES. Poles shall be Class 5, Type I or Type II (pentachlorophenol), as classified in Specification CAA-113, "Specification for Poles; Wood, Treated," and of the heights called for in the proposal.

106-2.4 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage shown on the plans/or proposal.

106-2.5 INSULATOR BRACKETS. Standard oak insulator brackets shall be similar and equal to Ranier Catalogue No. ROB-552-5.

106-2.6 POLE STEPS. Pole steps shall be galvanized iron, $\frac{5}{8}$ inch by 10 inches, similar and equal to the Hubbard Standard Hooks.

106-2.7 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces, and the mixing thereof, shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand designation. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type I.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) International-Orange paint for body and finish coats on metal and wood surfaces shall consist of a ready-mixed, bright, nonfading

¹ The winch can be detached and moved so that one winch will serve all the obstruction lights at the same station. The use of the winch is recommended for obstruction lights mounted over 75 feet above the control point.

International-Orange (orange-yellow No. 106) gloss paint, meeting the requirements of Federal Specification TT-P-59, Type B.

(d) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint, conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified International-Orange or white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

CONSTRUCTION METHODS

106-3.1 PLACING THE OBSTRUCTION LIGHTS. The contractor shall furnish and install single or double obstruction lights for series or multiple circuits, as specified in the proposal and shown on the plans. The obstruction lights shall be mounted on poles, buildings, or towers, approximately at the locations shown on the plan. The exact location shall be as directed by the engineer.

106-3.2 INSTALLATION ON POLES. If obstruction lights are to be mounted on poles, each obstruction light shall be installed with its hub at the same height as the top of the pole. All wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. If specified, pole steps shall be furnished and installed, the lowest step being five (5) feet above ground level. Steps shall be installed alternately on diametrically opposite sides of the pole to give a rise of 18 inches for each step. The upper step shall be not more than 18 inches below the top of the pole. Conduit shall be fastened to the pole with galvanized steel pipe straps, and shall be secured by galvanized lag screws. Straps shall be spaced at approximately 4-foot intervals, except that the uppermost strap shall be within 6 inches of the top of the pole and the next strap shall be $1\frac{1}{2}$ feet below the top strap. A standard oak insulator bracket shall be fastened to the pole at a suitable location for use as a bracket to hold the obstruction light globe during service operations. The underground portion of the conduit run shall be installed to a point 18 inches from the pole, in a direction indicated by the engineer, and at least 18 inches underground. A type C conduit fitting, with gasket and cast cover, shall be installed on the pole 3 feet above ground. The splice between underground supply cable and the wire shall be made, if necessary, at this point. Poles shall be painted with alternate bands of International-Orange and white, according with the color scheme shown on the plans. Top and bottom bands shall be International-Orange. Three coats of paint shall be applied (one prime, one body, and one finish coat) to all exposed material installed under this item, except the obstruction light globes.

When obstruction lights are to be installed on existing telephone or power poles, a fiber insulating sleeve not less than 4 feet long shall be installed to extend 6 inches above the conductors on the upper cross

arm and at least 18 inches below the conductor on the lower cross arm. The details of this installation shall be in accordance with the plans.

106-3.3 INSTALLATION ON BEACON TOWER. If specified on the plans, two obstruction lights shall be mounted on top of the beacon tower. The conduit shall screw directly into the obstruction light fixtures, and shall support them at a height equal to the highest point of the rotating beacon. All wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. If obstruction lights are specified at lower levels, the contractor shall install not less than one (1) inch galvanized rigid steel conduit with standard conduit fittings for mounting the fixtures. The fixtures shall be mounted in an upright position in all cases. The conduit shall be fastened to the tower members with "wraplock" straps, clamps, or approved fasteners, spaced approximately 5 feet apart. No conduit shall be laid on the beacon platform floor. Three coats of International-Orange shall be applied (one prime, one body, and one finish coat) to all exposed material installed under this item, except obstruction light globes.

106-3.4 INSTALLATION ON BUILDINGS, TOWERS, SMOKESTACKS, ETC. If obstruction lights are to be installed on buildings or similar structures, the installation shall be made in accordance with details shown on the plans. The hub of the obstruction light shall not be less than one (1) foot above the highest point of the obstruction, except in the case of smokestacks where the uppermost units shall be mounted about six (6) feet below the top of the stack. Conduit supporting the obstruction light units shall be fastened to wooden structures with galvanized steel pipe straps, and shall be secured to wood buildings by 1½ inch No. 10 galvanized wood screws. Conduit shall be fastened to masonry structures by the use of expansion shields, screw anchors, and toggle bolts using No. 10 or larger galvanized wood or machine screws. Conduit fastened to structural steel shall have the straps held with not smaller than No. 10 round head machine screws in drilled and tapped holes. Fastenings shall be approximately five (5) feet apart. Three coats of International-Orange shall be applied (one prime, one body, and one finish coat) to all exposed material installed under this item except obstruction light globes and, if used, operating parts of the disconnecting obstruction light.

106-3.5 INSTALLATION OF DISCONNECTING HANGERS. Where disconnecting hangers are specified for obstruction lights on smokestacks, radio towers, etc., they shall be installed in accordance with the installation details furnished by the manufacturer of the disconnecting hangers. The requirements of Paragraphs 3.4, 3.7, and 3.8 shall apply where applicable.

106-3.6 ISOLATING TRANSFORMERS. If series-multiple or series-series isolating transformers are specified, they shall be supplied in the sizes and types indicated in the proposal and installed at locations shown on, and in accordance with, the plans.

106-3.7 WIRING. The contractor shall furnish all necessary labor and materials, and shall make complete electrical connections from the underground cable or other source of power in accordance with the wiring diagram furnished with the project plans. If underground cable for the power feed and duct for this cable installation under paved areas is required, the cable and duct shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable," and Item L-110, "Installation of Underground Duct."

106-3.8 LAMPS. The contractor shall furnish and install in each unit one or two lamps, as required conforming to the following requirements:

- a. *Series Lamps*—A-21 bulb, $2\frac{3}{4}$ inches LCL, $5\frac{5}{16}$ inches maximum over-all length; medium prefocus base, 1020-lumen.
- b. *Multiple Lamps*—A-21 bulb, $2\frac{3}{4}$ inches LCL, $5\frac{5}{16}$ inches maximum over-all length; medium prefocus base, 110-watt.

106-3.9 PAINTING. The paint shall be applied uniformly in the proper consistency by skilled painters. The finished paint shall be free from sags, holidays, smears, and colors other than those specified. If the wrong color is spilled or applied to a surface, it shall be removed without damage to the surface from which removed. Each coat of paint shall be given ample time to dry and harden before the next coat of paint is applied. A minimum of three (3) days shall be allowed for drying on wood surfaces and a minimum of four (4) days shall be allowed for drying on metal surfaces. No painting shall be done in cold, damp, foggy, dusty, or frosty atmospheres, or when air temperature is below 40° F., or started when the weather forecast indicates such conditions for the day.

All surfaces shall be prepared for painting by cleaning. The surfaces shall be dry and free from scale, grease, rust, dust, and dirt when paint is applied. All knots in wood surfaces shall be killed with shellac immediately before applying the priming coat of paint. Nail holes and permissible imperfections shall be filled with putty.

The ready-mixed paint shall be thinned for the priming and body coats in accordance with the manufacturer's recommendations. In the absence of such recommendations, the following shall apply:

Body Coats (for both wood and steel surfaces)—Add one-half ($\frac{1}{2}$) pint of turpentine to each gallon of ready mixed paint for body coats.

Finish Coats (for both wood and steel surfaces)—The ready-mixed paint shall be used as it comes from the container for finish coats.

METHOD OF MEASUREMENT

106-4.1 The quantity of lights to be paid for under this item shall be the number of each type of obstruction light installed as completed units, in place, ready for operation, and accepted.

BASIS OF PAYMENT

106-5.1 Payment for lights shall be made at the contract unit price for each complete single or double, series or multiple, obstruction light, installed in place, and accepted by the engineer; which price and payment shall constitute full compensation for furnishing and installing the obstruction light; for furnishing and installing a wood pole or steel supporting pole or mast, if specified; for furnishing and installing conduit or fittings; for painting the wood pole or steel mast, if specified; for furnishing and installing the disconnecting hanger, if specified; for furnishing and installing an isolating transformer, if specified; for making all necessary cable connections; for painting all exposed material; for furnishing and installing lamp(s) and film cutout(s); for adjusting and testing, and for furnishing all testing equipment; and for all labor, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-106-5.1 Airport Obstruction Lights, in Place—per unit.

TABLE 1.—Obstruction Lights

Light	Globe	Fitting
Series Single Obstruction Light.....	{AN-2541-2 red prismatic..... AN-2541-12 red fresnel.....	AN-2547-1. Do.
Series Double Obstruction Light.....	{2-AN-2541-2 red prismatic..... 2-AN-2541-12 red fresnel.....	AN-2547-3. Do.
Multiple Single Obstruction Light.....	{AN-2541-2 red prismatic..... AN-2541-12 red fresnel.....	AN-2547-2. Do.
Multiple Double Obstruction Light.....	{2-AN-2541-2 red prismatic..... 2-AN-2541-12 red fresnel.....	AN-2547-4. Do.

ITEM L-107 INSTALLATION OF AIRPORT 12-FOOT WIND CONE

DESCRIPTION

107-1.1 This item shall consist of an airport wind cone furnished and installed in accordance with this specification, at the location and in conformity with the dimensions, design, and details shown on the plans.

Included in this item shall be the furnishing and installation of a support for mounting the wind cone, the furnishing and installation of underground cable, and a concrete foundation pad. This item shall also include all cable connections, conduit and conduit fittings, the furnishing and installation of all lamps, and the testing of the installation and all incidentals necessary to place the wind cone in operation as a completed unit, to the satisfaction of the engineer.

MATERIALS

107-2.1 WIND CONE. The wind cone shall conform to Specification AN-I-23, "Army-Navy Aeronautical Specification—Indicator Assemblies; Wind Cone; Unlighted and Externally Lighted," and shall be one of the following, as specified in the proposal:

Standard Types and Classes

- AN-2531-1 Type I (Beacon-Tower Mounted), Class A (unlighted).
- AN-2531-2 Type I (Beacon-Tower Mounted), Class B (lighted).
- AN-2531-3 Type II (Pipe-Mounted, Class A (unlighted).
- AN-2531-4 Type II (Pipe-Mounted), Class B (lighted).

When the contractor's bid is based on an approved unit, production sample and inspection test requirements are waived.

When the contractor's bid is based on a wind cone not previously approved, the factory inspection and tests and sample unit requirements described in Specification AN-I-23 shall not be waived.

107-2.2 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage specified on the plans and/or proposal.

107-2.3 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

107-2.4 CONCRETE. The concrete for pads shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

107-2.5 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces, and the mixing thereof, shall conform to the 95-

percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand designation. The raw linseed oil, turpentine, and dried shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type I.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) International-Orange paint for body and finish coats on metal or wood surfaces shall consist of a ready-mixed, bright, non-fading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of Federal Specification TT-P-59, Type B.

(d) White paint for body and finish coats on metal or wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified International-Orange or white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

CONSTRUCTION METHODS

107-3.1 GENERAL. The contractor shall furnish and install the wind cone on a building roof, on the ground or beacon tower, as shown on the plans.

107-3.2 INSTALLATION ON ROOF. Where the wind cone is to be installed on a roof, it shall be mounted on a hinged support constructed and installed in accordance with details shown on the plans. The support shall be carried through the roofing surface, and shall be securely attached and braced to the roof trusses, and the roof resealed. The support shall be guyed with one-quarter ($\frac{1}{4}$) inch guy strand, complete with suitable galvanized turnbuckle and clevis assembly. A guy fastening shall be installed.

107-3.3 INSTALLATION ON FIELD. Where the wind cone is to be installed on the field, it shall be mounted on a concrete foundation, and a hinged support constructed and installed as shown on the plans.

107-3.4 INSTALLATION ON BEACON TOWER. Where the wind cone is to be installed on a beacon tower, the wind cone shall be mounted on the tower wind cone bracket supplied with the tower.

107-3.5 ELECTRICAL CONNECTION. The contractor shall furnish all labor and materials and shall make complete electrical connections in accordance with the wiring diagram furnished with the project plans.

All wiring to wind cones mounted on buildings or beacon tower shall be run in not less than one (1) inch galvanized rigid steel conduit. If underground cable from the transformer vault to the wind cone site and duct for this cable installation under paved areas is required, the cable and duct shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable," and Item L-110, "Installation of Underground Duct."

107-3.6 BOOSTER TRANSFORMER. When specified, the contractor shall furnish and install a booster autotransformer to compensate for voltage drop to the lamps. The booster transformer shall be installed in a suitable weatherproof housing, as indicated on the plans. If this booster transformer is required for installation in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

107-3.7 PAINTING. Three coats of International-Orange paint shall be applied (one prime, one body, and one finish) to all exposed material installed under this item, except the fabric cone, obstruction light globe and lamp reflectors. The AN-I-23 wind-cone assembly which, if painted on receipt, shall be given one finish coat of International-Orange in lieu of these coats specified.

107-3.8 LAMPS. The contractor shall furnish and install four 200-watt, 115-volt general lighting service lamps in the reflectors. A clear 100- or 111-watt, 115-volt traffic signal lamp with a medium screw base; or 100-watt, A-21 bulb, 115-volt, medium prefocus base lamp shall be furnished and installed in the obstruction light as required.

METHOD OF MEASUREMENT

107-4.1 The quantity of cones to be paid for under this item shall be the number of wind cones installed as completed units in place, ready for operation, and accepted.

BASIS OF PAYMENT

107-5.1 Payment for cones shall be made at the contract unit price for each complete wind cone furnished and installed in place by the contractor and accepted by the engineer; which price and payment shall constitute full compensation for furnishing, installing, and erecting the wind cone and, if required, the foundation and the hinged support; for painting all exposed material; for painting the roof, if specified; for furnishing and installing guy wire, if specified; for furnishing and installing a booster transformer, if specified; for all wiring, lamps, and conduit, and for making all necessary connections; for adjusting and testing, and for furnishing all test equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-107-5.1 Airport 12-Foot Wind Cone, in Place—per unit.

ITEM L-108 INSTALLATION OF AIRPORT UNDERGROUND CABLE FOR LARGE AIRPORTS

DESCRIPTION

108-1.1 This item shall consist of underground cable furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, designs, and details shown on the plans. This item shall include the excavation and backfill of trench, and the installation of cable installed in trench, in duct, or conduit. It shall include all splicing, cable marking, and testing of the installation and all incidentals necessary to place the cable in operating condition as a completed unit, to the satisfaction of the engineer. This item shall not include the installation of the duct or conduit.

MATERIALS

108-2.1 CABLE. Underground cable shall conform to the requirements of Specification L-824, "Underground Electrical Cables for Airport Lighting Circuits," unless otherwise specified. Cable type, size, number of conductors, and service voltage shall be as specified on the plans and/or proposal.

108-2.2 TAPE. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Friction tape shall conform to Federal Specification HH-T-101.

108-2.3 SPLICE BOXES. Underground cable splice boxes shall be constructed of fiber, and shall be in accordance with the details shown on the plans.

108-2.4 CONCRETE. Concrete for cable markers shall conform to Item P-610, "Structural Portland Cement Concrete."

108-2.5 INSULATING COMPOUND. Insulating compound shall be similar and equal to "Ozite B," as manufactured by the General Cable Corporation.

CONSTRUCTION METHODS

108-3.1 GENERAL. The contractor shall install the specified cable at the approximate locations indicated on the airport lighting lay-out plans. The engineer shall indicate specific locations. No cable splices shall be made between runway marker lights spaced less than 220 feet apart. Splices may be made elsewhere only when specifically authorized in writing by the engineer.

108-3.2 INSTALLATION IN DUCT OF CONDUIT. This item includes the installation of the cable in duct or conduit as described below. The maximum number and voltage ratings of cables installed in each single duct or conduit, and the current carrying capacity of each cable, shall be in accordance with the latest National Electrical Code, or local code agency having jurisdiction.

The contractor shall make no splices or joints of any kind in cables installed in conduits or ducts.

The duct or conduit shall be installed as a separate item; however, the contractor shall make sure that the duct is open, continuous, and clear of debris before installing cable. The cable shall be installed in such manner and by such methods to insure against harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. No splices or joints will be permitted to be drawn inside ducts. Where more than one cable is to be installed in a duct under the same contract, all shall be pulled in the duct at the same time. Duct or conduit markers temporarily removed for excavations shall be replaced as required.

108-3.3 TRENCHING. Trenches for cables may be excavated manually or with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed. Road patrols or graders shall not be used to excavate the trench with their blades. The bottom surface of trenches shall be essentially smooth and free from coarse aggregate.

Unless otherwise specified, cable trenches shall be excavated to a minimum depth of eighteen (18) inches below finished grade, except as follows:

- a. When off the airport or crossing under a roadway or driveway the minimum depth shall be 36 inches, unless otherwise specified.
- b. Minimum cable depth when crossing under a railroad track shall be 42 inches, unless otherwise specified.

The contractor shall excavate all cable trenches to a width not less than three (3) inches and not wider than twelve (12) inches. The trench shall be widened where more than two cables are to be installed parallel in the same trench, as required for the proper cable separation described below. Unless otherwise specified on the plans, all cables in the same location and running in the same general direction shall be installed in the same trench.

When rock excavation is encountered, the rock shall be removed to a depth of at least three (3) inches below the required cable depth. The contractor shall ascertain the type of soil or rock to be excavated before bidding.

108-3.4 INSTALLATION IN TRENCHES. The contractor shall not use a cable plow for installing the cable, unless authorized in writing by the engineer.

Bends or kinks of a radius less than 10 times the diameter of the cable shall not be permitted.

Cables shall be unreeled in place alongside or in the trench, and shall be carefully placed along the bottom of the trench. Under no condition shall the cable be unreeled and pulled into the trench from one end.

Where two or more cables are laid parallel in the same trench, they shall be spaced laterally, a minimum distance of 3 inches apart, and the trench shall be widened sufficiently to accomplish this.

Cables crossing over each other shall have a minimum of 3-inch vertical displacement with the topmost cable kept at or below the minimum required depth below finished grade.

Where specified on the plans, the cable in the trench shall be protected by the installation of a 1-inch thick creosoted wood plank or planks. Before laying the planks in the trench, a 3-inch layer of sand or clean earth, free from any mineral aggregate particles that would be retained on a $\frac{1}{4}$ -inch sieve, shall be placed over the cable and tamped to the approximate density of the adjacent undisturbed soil. The planks shall then be laid end to end in the trench to cover the cable, or cables, after which the trench shall be backfilled and compacted, as specified elsewhere in this section.

To allow for ground settlement, approximately 1 foot of cable slack shall be left on each side of all splice boxes, insulating transformers, light units, and at all other points where cable connections are brought above ground. The slack cable shall be placed in the trench in a series of "S" curves. Where cable is brought above ground, sufficient slack cable shall be left to make the required connections. The amount of slack cable shall be stipulated by the engineer.

108-3.5 BACKFILLING. After the cable has been installed, the trench shall be backfilled. The first layer of backfill shall be three (3) inches thick, loose measurement, and shall be either earth or sand containing no mineral aggregate particles that would be retained on a $\frac{1}{4}$ -inch sieve. The second layer shall be five (5) inches deep, loose measurement, and shall contain no particles that would be retained on a 1-inch sieve. The remainder of the backfill shall be excavated or imported material, and shall not contain stone or aggregate larger than four (4) inches maximum diameter. The third and subsequent layers of the backfill shall not exceed eight (8) inches in maximum depth, loose measurement.

All backfill material shall be thoroughly tamped and compacted to at least ninety (90) percent of maximum density at optimum moisture, as determined by CAA compaction control tests T-611, for the class of airport involved. If necessary to obtain the desired compaction, the backfill material shall be moistened or aerated as required.

Trenches shall not be excessively wet and shall not contain pools of water during backfilling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface, except that when sod is to be placed over the trench the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Trenches in solid rock shall be backfilled with a 3-inch layer, compacted measurement, of bedding material before installation of the cable. The bedding layer shall be tamped and compacted to the density specified above, and shall be earth or sand containing no mineral aggregate particles that would be retained on a $\frac{1}{4}$ -inch sieve.

108-3.6 RESTORATION. Any excess excavated material shall be removed and disposed of in accordance with instructions issued by the engineer. After backfilling, the surface shall be left free from ruts and rough spots and restored to its original condition. Where turf is well established and the sod can be moved, it shall be carefully stripped, properly stored, and replaced as soon as possible after the backfilling is completed. Where turfing work has been done, but where turf is not established, the lighting contractor shall restore to its original condition all areas disturbed by the trenching, storing of dirt, cable laying, pad construction, and other work. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, topsoil planting, or mulching. The work shall be performed in accordance with the CAA Standard Turfing Specifications, as directed by the engineer. The contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance.

108-3.7 CABLE MARKERS. The location of runway and boundary light circuit lead-ins shall be marked by a concrete slab marker two (2) feet square and four (4) inches thick. Each cable run from the line of runway lights to the equipment vault shall be marked at the point where the cable leaves the contact light trench along the runway, and shall also be marked at approximately every 200 feet along the cable run, with an additional marker at each change of direction of cable run.

All other cable buried directly in the earth shall be marked in the same manner. The contractor shall not install slab markers where cable lies in straight lines between obstruction light poles which are spaced 300 feet apart or less. Cable markers shall be installed flat in the ground immediately above the cable, with approximately 1 inch projecting above the surface. The contractor shall impress the word "cable" on each cable-marking slab. He also shall impress additional circuit identification symbols on each slab, if so directed by the engineer. The letters shall be approximately 4 inches high and 3 inches wide, with width of stroke $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch deep.

The location of each underground cable splice also shall be marked by a concrete marker slab placed above the splice, with approximately 1 inch of the slab projecting above the surface. The concrete marker shall be as described above. The contractor shall impress the word "splice" on each splice-marking slab. He also shall impress additional circuit identification symbols on each slab, if so directed by the engineer. The letters shall be approximately 4 inches high and 3 inches wide, with width of stroke $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch deep.

108-3.8 SPLICING. A fiber splice box shall be used, and shall be constructed and installed as shown on the plans. The contractor shall drill the two end caps of the box to fit the outside diameter of the cable, and both caps and the body of the splice box shall be threaded on the cables *before any splicing is started*. One

end cap shall be placed on each of the two cable ends with the cap flanges facing the splice and with the splice box body threaded on one of the cables so as to be between the two end caps. The splice shall be centered in the body of the box and the end caps replaced upon completion of the splices. If necessary, the cable entrance holes shall be caulked to prevent the compound from leaking out.

The contractor shall furnish and pour the insulating compound in the splice boxes. After the compound has partly cooled and contracted, and in not less than 30 minutes, additional compound shall be added until the box is completely filled. Pouring temperatures shall be as recommended by the manufacturer of the compound, and shall be measured by a thermometer. In the absence of a recommended temperature, pouring temperature in winter shall be approximately 450° F., and approximately 400° F. in the summer. During the pouring of the compound, care shall be exercised to insure that all air is allowed to escape from the interior of the splice box.

Western Union type splices or split copper connectors of the proper size for the conductor shall be used. Sufficient insulation shall be thoroughly removed from each conductor to permit a mechanically secure splice with the bare conductors when the Western Union joint is used. The ends of the insulation shall be penciled down for a distance of approximately six times the insulation thickness, and bare wires shall be made bright and clean for both types of splice.

Before soldering, the contractor shall install the connector or make a Western Union joint which is both mechanically and electrically secure, and shall temporarily wrap the ends of the insulation while soldering to prevent burning the insulation. All splices shall be soldered, using a noncorrosive paste flux.

All splices shall be covered with rubber tape insulation to approximately one and one-half ($1\frac{1}{2}$) times the thickness of the original insulation of the cable. The rubber insulation shall be tightly wrapped with friction tape in half-lap wrappings which shall overlap the undisturbed outside surface of the cables. The completed splice shall be given a coat of weatherproof paint which shall be allowed to dry before the splice box is filled with compound.

108-3.9 TESTING. The contractor shall furnish all necessary equipment and appliances for testing the underground cable circuits after installation. The contractor shall test and demonstrate, to the satisfaction of the engineer, the following:

- a. That all lighting, power, and control circuits are continuous and free from short circuits.
- b. That all circuits are free from unspecified grounds.
- c. That the resistance to ground of all nongrounded series circuits is not less than 50,000 ohms.
- d. That the resistance to ground of all nongrounded conductors of multiple circuits is not less than 100,000 ohms.

- e. That all circuits are properly connected in accordance with the applicable wiring diagrams.
- f. That all circuits are operable, which demonstration shall include functioning of each control not less than ten (10) times, and continuous operation of each lighting and power circuit for not less than one-half ($\frac{1}{2}$) hour.

METHOD OF MEASUREMENT

108-4.1 The quantity of trench to be paid for shall be the linear feet of trench, including the excavation, backfill, and reconditioning, completed, measured as excavated, and accepted as satisfactory.

Separate measurement shall be made for trenches excavated for the installation of one cable, and for the installation of two or more cables.

108-4.2 The footage of cable installed in trench to be paid for shall be the number of linear feet of cable installed in trench measured in place, completed, ready for operation, and accepted as satisfactory.

Separate measurement shall be made for each cable installed in trench, and for the different kinds of cable.

108-4.3 The footage of cable installed in conduit to be paid for shall be the number of linear feet of cable installed in duct or conduit, measured in place, completed, ready for operation, and accepted as satisfactory.

Separate measurement shall be made for each cable installed in duct or conduit, and for the different kinds of cable.

BASIS OF PAYMENT

108-5.1 The footages of trench or cable, measured as provided above, shall be paid for at the contract unit price for each linear foot of trench and per linear foot of cable installed in the trench or duct in place by the contractor and accepted by the engineer. The trenching shall be paid for on an unclassified basis, and no allowance shall be made for rock or other special conditions encountered. The price and payment shall constitute full compensation for furnishing and placing cable and all other necessary materials; for locating and cleaning duct lines; for pulling cables in ducts; for all trenching including excavation, backfill, and reconditioning; for installing planks and cable markers; for splicing, where required and permitted; for disposal of surplus materials; for testing of all completed circuits or portions thereof; and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

- Item L-108-5.1 Airport Cable Trench—per linear foot.
- Item L-108-5.1 Airport Underground Cable, installed in trench—per linear foot.
- Item L-108-5.1 Airport Underground Cable, installed in conduit—per linear foot.

ITEM L-109 INSTALLATION OF AIRPORT TRANS- FORMER VAULT AND EQUIPMENT

DESCRIPTION

109-1.1 This item shall consist of an airport transformer vault constructed and installed in accordance with this specification at the location and in conformity with the dimensions and design shown on the plans. Included in this item shall be the furnishing and installing of all vault equipment, wiring, buses, cable, conduit, duct, potheads, and grounding system. This work shall also include the painting of the vault and equipment; the marking and labeling of equipment and tagging of wires; the testing of the installation; and the furnishing of all incidentals necessary to place it in operating condition as a completed unit, to the satisfaction of the engineer.

MATERIALS

109-2.1 CONCRETE. The concrete for the vault shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete," using $\frac{3}{4}$ -inch maximum size coarse aggregate.

109-2.2 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed-type bars, and shall meet the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

109-2.3 BRICK. Brick shall conform to A. S. T. M. Designation C-62, Grade SW.

109-2.4 ASBESTOS CEMENT DUCT. Asbestos cement duct and fittings shall be in accordance with Federal Specification W-C-571.

109-2.5 FIBER CONDUIT. Fiber conduit and fittings shall be in accordance with Federal Specification W-C-581.

109-2.6 RIGID STEEL CONDUIT. Rigid steel conduit and fittings shall be in accordance with Federal Specification WW-C-581.

109-2.7 HIGH VOLTAGE BUS. High voltage bus shall be standard weight $\frac{3}{8}$ -inch IPS copper tubing.

109-2.8 BUS CONNECTORS. Connectors shall be similar and equal to Burndy Type NT.

109-2.9 BUS SUPPORTS. Bus supports shall be similar and equal to Westinghouse No. 527892, insulated for 7,500 volts, single clamp type for two-bolt flat mounting.

109-2.10 GROUND BUS. Ground bus shall be $\frac{1}{8}$ x $\frac{3}{4}$ -inch copper bus bar.

109-2.11 SQUARE DUCT. Duct shall be of the square type similar and equal to that manufactured by the Square D Company, or the Trumbull Electric Manufacturing Company. The entire front of the duct on each section shall consist of hinged or removable cover for ready access to the interior. Cross-section of the duct shall be not less than 4 inches x 4 inches, except where otherwise shown on the plans.

109-2.12 GROUND RODS. Ground rods shall be $\frac{5}{8}$ inch x 10 feet in accordance with Specification CAA-233, "Ground Rods."

109-2.13 POTHEADS. Potheads shall be similar and equal to G & W Type N, Shape C. Potheads shall be furnished with plain insulator bushings and conduit couplings. Potheads shall have a voltage rating at least equal to the circuit voltage.

109-2.14 LIGHTING. Vault lighting fixtures shall be vapor-proof type similar and equal to Crouse-Hinds Company Catalogue No. VA 189, or to Benjamin Electric Company Catalogue No. 7111A.

109-2.15 OUTLETS. Convenience outlets shall be duplex units similar and equal to Hubbel No. 6257.

109-2.16 SWITCHES. Vault light switches shall be single pole switches similar and equal to Bryant Type No. 3951.

109-2.17 OTHER ELECTRICAL EQUIPMENT. Constant current regulators, distribution transformers, oil switches, cut-outs, relays, terminal blocks, transfer relay, circuit breakers, and all other regularly used commercial items of electrical equipment not covered by the above specifications shall conform to the applicable rulings and standards of the American Institute of Electrical Engineers or the National Electric Manufacturers Association for equipment of this type. Manufacturers certification or test reports from a testing laboratory, to the effect that the equipment meets these specifications, shall be supplied when requested by the engineer. Such equipment shall, in all cases, be new and first-grade products. This equipment shall be supplied in the quantities required for the specific project, and shall incorporate the electrical and mechanical characteristics specified in the proposal and plans.

109-2.18 FLOOR DRAIN. The floor drain shall be similar and equal to type Z-798-A, as manufactured by the Z. A. Zurn Manufacturing Company.

109-2.19 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces, and the mixing thereof, shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type I.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration from sulphide fumes.

(c) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

(d) Paint for floor, ceiling, and inside walls shall be in accordance with Federal Specification TT-P-146. Walls and ceiling shall be light gray No. 124; floor shall be medium gray No. 123, as described on the Color Card Supplement to U. S. Army Specification 3-1.

(e) The roof coating shall be in accordance with Federal Specification SS-R-451.

109-2.20 WIRE. Wire shall conform to Federal Specification J-C-103, Type R or RH, and shall be of size and insulation to conform to the following:

a. *Control Circuits.* Wire shall not be smaller than No. 14 AWG, and shall be insulated for 600 volts.

b. *Power Circuits.*

1. Less than 600 volts—Wire shall be No. 6 AWG or larger, and insulated for at least 600 volts.
2. Over 600 but less than 3,000 volts—Wire shall be No. 6 AWG or larger, and insulated for at least 3,000 volts.
3. Over 3,000 volts—Wire shall be No. 6 AWG or larger, and insulated for at least the circuit voltage.

CONSTRUCTION METHODS

109-3.1 GENERAL. The contractor shall construct the transformer vault at the location indicated on the airport lighting layout plans and as staked out by the engineer. The vault shall be the type shown on the plans. Construction shall be reinforced concrete throughout, unless brick wall construction is specified.

The contractor shall clear, grub, grade, and seed the area around the vault for a minimum distance of 10 feet on all sides. The slope shall be not less than $\frac{1}{2}$ -inch per foot away from the vault in all directions. The contractor shall furnish, install, and connect all equipment, together with all accessory equipment, conduits, cables, wires, and supports necessary to insure a complete and operable lighting distribution center for the airport, as specified herein and shown on the plans.

109-3.2 FOUNDATION AND WALLS. (a) *Reinforced Concrete Construction.* The contractor shall construct the foundation and walls in accordance with the details shown on the plans. Unless otherwise specified internal ties shall be used for holding the wall forms. These ties shall be of the mechanical type so that when the

forms are removed the ends of the ties shall be at least 1 inch beneath the concrete surface, and the holes shall be plugged and finished to prevent discoloration. Reinforcing steel shall be placed, as shown on the drawings, and secured in position to prevent displacement during the pouring of the concrete. Concrete for foundation and walls shall be poured monolithically.

The external surfaces of the concrete shall be thoroughly worked during the operation of placing in such manner as to force all coarse aggregate from the surface and thoroughly work the mortar against the forms to produce a smooth finish free from air pockets and honeycomb.

The surface film of all pointed surfaces shall be removed before setting occurs. As soon as the pointing has set sufficiently to permit, the entire surface inside and outside of the vault shall be thoroughly wet with water and rubbed with a No. 16 carborundum stone, or equal quality abrasive, bringing the surface to a paste. All form marks and projections shall be removed. The surface produced shall be smooth and dense without pits or irregularities. The material which has been ground into a paste during the rubbing process shall be spread or brushed uniformly over the entire surface (except the interior surfaces that are to be painted shall have all paste removed by washing before painting) and permitted to reset. Final exterior finish shall be obtained by rubbing with No. 30 carborundum stone or an equal quality abrasive. The surface shall be rubbed until entire surface is smooth and uniform in color.

(b) *Brick and Concrete Construction.* When this type of construction is specified, the foundation shall be concrete conforming to the details shown on the plans. The outer edge of the foundation at the floor level shall be beveled $1\frac{1}{2}$ inches at 45 degrees. Brick walls shall be 8 inches thick, laid in running bond with every sixth course a header course. Brick shall be laid in cement mortar (1 part masonry cement and 3 parts sand) with full mortar bed and shovelled joints. All joints shall be completely filled with mortar, and facing brick shall be back-parged with mortar as work progresses. All joints shall be $\frac{3}{8}$ -inch thick and exterior joints, tooled concave and interior joints, struck flush. Both interior and exterior brick surfaces shall be cleaned and nail holes, cracks and other defects filled with mortar. When specified, a nonfading mineral pigment mortar coloring shall be added to the mortar. Steel reinforcing bars, $\frac{3}{8}$ inch in diameter and 12 inches long, shall be set vertically in the center of the brick wall on not more than 2-foot centers to project $2\frac{1}{2}$ inches into the concrete roof slab. Lintels for supporting the brickwork over doors, windows, and louvres shall consist of two 4 inch x 3 inch x $\frac{3}{8}$ inch steel angles. Lintels shall be painted one coat of red lead before installation, and all exposed parts shall be painted similar to doors and window sash after installation.

Window sills shall be concrete poured in place. All exposed surfaces shall have a rubbed finish, as specified under reinforced concrete

construction. On completion, all interior and exterior faces of walls shall be scrubbed with a solution of muriatic acid and water in the proportions of not less than one (1) part acid to ten (10) parts of water. All traces of efflorescence, loose mortar, and mortar stain shall be removed, and the walls washed down with clear water.

109-3.3 ROOF. The roof shall be reinforced concrete, as shown on the plans. Reinforcing steel shall be placed as shown on the drawing and secured in position to prevent displacement during the pouring of concrete. The concrete shall be poured monolithically, and shall be free of honeycombs and voids. The surface shall have a steel-troweled finish, and shall be sloped as shown on the drawing. The underside of the roof slab shall be finished in the same manner as specified for walls.

One brush or mop coat of hot asphalt roof coating shall be applied to the top surface of the roof slab. The asphalt material shall be heated to within the range specified by the manufacturer and immediately applied to the roof. The finished coat shall be continuous over the roof surface and free from holidays and blisters. Smears and dribbles of asphalt on the roof edges and building walls shall be removed.

109-3.4 FLOOR. The floor shall be reinforced concrete, as shown on the drawings. When present, all sod, roots, refuse, and other perishable material shall be removed from the area under the floor to a depth of eight (8) inches, unless a greater depth is specified in the invitation for bids. This area shall be backfilled with material consisting of sand, cinders, gravel, or stone. Fill shall be placed in layers not to exceed four (4) inches, and shall be thoroughly compacted by tamping or rolling. A layer of building paper shall be placed over the fill prior to placing concrete. The floor surface shall be a steel-troweled finish. The floor shall be level unless a drain is specified, in which case the floor shall be pitched $\frac{1}{4}$ -inch per foot downward toward the drain. Expansion joints between floor and foundation walls shall be filled with $\frac{1}{4}$ -inch asphalt felt. The floor shall be poured monolithically, and shall be free of honeycombs and voids.

109-3.5 FLOOR DRAIN. Where shown on the plans, a floor drain and dry well shall be installed in the center of the floor of the equipment room. The dry well shall be excavated 4 feet by 4 feet in plan to a depth of 4 feet below the finished floor elevation, and shall be backfilled to the elevation of the underside of the floor with gravel which shall all pass a 2-inch mesh sieve, and shall all be retained on a $\frac{1}{4}$ -inch mesh sieve. The gravel backfill shall be placed in 6-inch maximum layers, and the entire surface of each layer shall be tamped either with a mechanical tamper or with a hand tamper weighing not less than 25 pounds and having a face area of not more than 36 square inches nor less than 16 square inches. The drain inlet shall be set flush in the concrete floor. The drain shall have a clear opening of not less than 8 inches in diameter.

109-3.6 CONDUITS IN FLOOR AND FOUNDATION. Conduits shall be installed in the floor and through the foundation walls, in accordance with the details shown on the plans. All underground conduit shall be painted with a bituminous compound. Conduit shall be installed with a coupling or metal conduit adapter flush with top of floor. All incoming conduit shall be closed with a pipe plug to prevent the entrance of foreign material during construction. Spare conduit entrances shall be left closed.

109-3.7 PAINTING. The floor, ceiling, and inside walls shall first be given a hardening treatment, after which the contractor shall apply two coats of paint as specified below. The hardening treatment shall consist of applying two coats of either a commercial floor hardener or a solution made by dissolving 2 pounds of magnesium fluosilicate or zinc sulphate crystals in 1 gallon of water. Each coat shall be allowed to dry at least 48 hours before the next application. After the second treating coat has dried, the surfaces shall be brushed clean of all crystals and thoroughly washed with clear water. Paint for walls and ceiling shall be colored to match light gray color No. 124 of Color Card Supplement to U. S. Army Specification No. 3-1, or as directed by the engineer. The floor paint shall be colored to match medium gray color No. 123 of the above-mentioned color card, or as directed by the engineer. Before painting, the surfaces shall be dry and clean. The first coat shall be thinned by adding $\frac{2}{3}$ quart of spar varnish and $\frac{1}{3}$ quart of turpentine to each gallon of paint. The second coat shall be applied without thinning. The painting of interior brick walls is not required. All doors, lintels, and windows shall be cleaned to remove any rust or foreign material, and shall be given one body and one finish coat of white paint. Bare metal surfaces shall first be given a prime coat of red lead.

109-3.8 INSTALLATION OF VAULT EQUIPMENT. The contractor shall furnish and install all material and equipment required to form a complete operating unit in the vault, as stipulated in the proposal and shown on the plans. The complete installation and wiring shall be done in a neat, workmanlike manner. The number of conductors and sizes (if other than specified in Section 2.20) shall be as shown on the plans.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and local code agency having jurisdiction. The transformers and regulators shall be set on steel "H" sections, "I" beams, or channels, or on concrete blocks so as to provide a minimum space of $1\frac{1}{2}$ inches between the equipment and the floor. The equipment shall be placed so as not to obstruct the oil-sampling plugs of the oil-filled units; and name plates shall, so far as possible, not be obscured.

Wall- or ceiling-mounted equipment shall be attached to the wall or ceiling with galvanized bolts of not less than $\frac{3}{8}$ -inch diameter engaging metal expansion shields or anchors.

The contractor shall furnish and install square-type exposed metallic duct for the control circuits in the vault. These shall be mounted along the walls behind all floor-mounted equipment, and immediately below all wall-mounted equipment.

Wall brackets for square duct shall be installed at all joints 2 or more feet apart, with intermediate brackets at the contractor's option. Conduit shall be used between square duct and equipment when the equipment is designed for conduit connection. When the equipment is not designed for conduit connection, conductors shall enter the duct through insulating bushings in the duct or on conduit risers.

Underground cable will be installed to the approximate locations outside the walls of the transformer vault as a separate item. The contractor installing the vault equipment shall bring the cables from the trench or duct through the entrance conduits into the vault and make the necessary electrical connections.

For the incoming and outgoing power circuits the contractor shall furnish and install rigid metallic conduit risers, surmounted by pot-heads, from floor level to the equipment as shown on the plans.

The contractor shall furnish and install a minimum of two duplex convenience outlets in the vault room and one duplex convenience outlet in the control room, as shown on the plans. The vault and control room lights and switches shall be installed in accordance with the plans.

The contractor shall make all necessary electrical connections in accordance with the wiring diagrams furnished, and as directed by the engineer.

In wiring to the terminal blocks the contractor shall leave sufficient extra length on each control lead to make any required changes in connections at the terminal block.

When specified, the contractor shall furnish and install a booster auto-transformer, or auto-transformers, to compensate for voltage drop to the beacon and/or wind cone and/or wind tee lamps. This transformer shall be installed as shown on the plans, and the electrical characteristics shall be as described in the proposal.

Five spare fuses for each type used in the vault shall be supplied by the contractor and stored in the vault.

109-3.9 MARKING AND LABELING. All equipment, control wires, terminal blocks, etc., shall be tagged, marked or labeled as specified below:

(a) *Tags.* The contractor shall furnish and install identifying tags on all control wires at the point where they connect to control equipment or to terminal blocks. Tags shall be of fiber not less than $\frac{3}{4}$ inch in diameter and not less than $\frac{1}{32}$ inch thick. Identification markings designated on the plans shall be stamped on tags by means of small tool dies. Each tag shall be securely tied to the proper wire by nonmetallic cord.

(b) *Wiring Diagram.* The contractor shall furnish a wiring diagram showing final connections. The diagram shall be installed on a

wall of the vault room under glass in a $1\frac{1}{2}$ inch wide by $\frac{3}{4}$ inch thick wood frame. The diagram shall be mounted where directed by the engineer.

(c) *Labels.* The contractor shall stencil identifying labels on the cases of regulators, breakers, and distribution and control relays with white oil paint, as designated by the engineer. The contractor shall also mark the correct circuit designations in accordance with the wiring diagram on the terminal marking strips which are a part of each terminal block.

(d) *Cards.* Where equipment is furnished with cardholders, the contractor shall furnish cards, if necessary, and shall print or type the correct circuit designations on the cards. Each card shall be protected with a transparent plastic cover furnished, if necessary, by the contractor.

(e) *Signs.* The contractor shall furnish and install a sign on the control room side of the inner vault fireproof door, at an approximate elevation of 5 feet. The sign shall be enameled metal containing the words "DANGER" and "HIGH VOLTAGE" on it (red-on-white, or white-on-red) in letters at least 2 inches high.

109-3.10 GROUNDING. (a) The contractor shall furnish and install a permanent and effective grounding system for all transformer and switch cases, panelboard and relay cabinets, outlet boxes, pull boxes, conduit, and all other noncurrent-carrying parts of the vault and control room equipment. At least two artificial grounding electrodes shall be furnished and installed outside the building by the contractor for the equipment grounding system.

The contractor shall also furnish and install a separate ground for the neutral conductor of the secondary of the distribution transformer in the vault. At least two artificial grounding electrodes shall be furnished and installed outside the vault for the neutral conductor ground. These shall be in addition to the grounding electrodes prescribed above for the equipment grounding system.

Both the equipment grounding system and the neutral conductor grounding system shall be electrically connected together inside the vault.

(b) *Rods.* Ground rods installed outside the vault shall be spaced at least 6 feet apart and at least 3 feet from the vault foundation. The rods shall be driven into the ground so that the top is at least 6 inches below grade.

(c) *Plates.* Where rock conditions prevent the driving of ground rods, as specified above, grounding plates may be used if authorized by the engineer. A minimum of three plates spaced at least 6 feet apart and at least 3 feet from the vault foundation shall be used for each separate ground. Each plate shall be of nonferrous metal not less than 18 inches square and not less than 0.06 inch thick. Plates shall be embedded below permanent moisture level, unless otherwise specified. The plates shall be set in a horizontal plane,

as deep as possible in rock fissures or depressions to obtain the best available ground. There shall be a minimum of 3 inches of earth under the plate, and a minimum of 1 foot of earth backfilled above the plate with the backfill approximately flush with the surrounding surface.

(d) *Grounding Conductors.* The ground bus inside the vault shall be mounted $\frac{1}{4}$ -inch out from the wall and 6 inches above the floor. Connections to the ground bus bar from the equipment and to ground rods or plates shall be No. 6 bare copper wire or larger. The grounding conductors shall be attached to the bus bar and to circuits, conduits, cabinets, equipment, and ground rods or plates by means of suitable lugs, pressure connectors, or clamps. Connections which depend upon solder shall not be used.

(e) *Resistance.* The resistance to ground of any part of the grounding system shall not exceed 10 ohms.

109-3.11 TESTING. The installation shall be tested in operation as a completed unit prior to acceptance. Tests shall include resistance, voltage, and current readings, as required by the engineer. Testing equipment shall be furnished by the contractor. Tests shall be conducted as directed by the engineer and shall be to his satisfaction. The contractor shall be responsible for all equipment and materials furnished, and any equipment or materials found to be defective or damaged shall be replaced by the contractor at his own expense.

METHOD OF MEASUREMENT

109-4.1 The quantity of vaults to be paid for under this item shall consist of the number of vaults constructed in place with all equipment installed and connected, ready for operation, and accepted as a complete unit.

BASIS OF PAYMENT

109-5.1 Payment for vaults shall be at the contract unit price for each complete vault installation in place and accepted, which price and payment shall constitute full compensation for clearing, grubbing, excavating, and seeding the site; constructing a transformer vault of the type specified, including foundation, walls, floor slab, roof, all doors, windows, and ventilator openings; for finishing and painting all interior and exterior surfaces of the vault, including walls, floor, roof, doors, lintels, and windows as specified; for furnishing and installing floor drain and dry well, if specified; for furnishing and installing all conduit in the floor and ceiling, and through the walls and foundation walls; for furnishing and installing vault and control-room lights, switches, lamps, and convenience outlets; for furnishing, installing, and mounting in place in the vault all material and equipment required to form a complete operating unit, including all transformers, constant-current regulators, oil switches, cutouts, relays, potheads, terminal blocks, booster transform-

ITEM L-110 INSTALLATION OF AIRPORT UNDERGROUND ELECTRICAL DUCT

DESCRIPTION

110-1.1 This item shall consist of underground electrical duct installed in accordance with this specification at the locations and in conformity with the dimensions, designs, and details shown on the plans. This item shall include the installation of all underground electrical duct or underground conduit, and shall also include all trenching, backfilling, removal, and restoration of any paved areas, manholes, concrete, mandreling, installation of steel drag wires and duct markers, capping, and the testing of the installation as a completed duct system, to the satisfaction of the engineer, and ready for installation of cables.

MATERIALS

110-2.1 BITUMINOUS FIBER DUCT. Bituminous fiber duct and fittings shall conform to the requirements of Federal Specification W-C-581, and shall be one of the following as specified in the proposal:

- a. Type I for concrete encasement.
- b. Type II for direct burial.

110-2.2 ASBESTOS CEMENT DUCT. Asbestos cement duct and fittings shall conform to the requirements of Federal Specification W-C-571, and shall be one of the following as specified on the proposal:

- a. Type I for concrete encasement.
- b. Type II for direct burial.

110-2.3 TERRA COTTA DUCT. Terra cotta duct and fittings shall be of first-grade commercial quality.

110-2.4 STEEL CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

110-2.5 CONCRETE. Concrete shall conform to Item P-610, "Structural Portland Cement Concrete," using 1-inch maximum size coarse aggregate.

CONSTRUCTION METHODS

110-3.1 GENERAL. The contractor shall install underground duct at the approximate locations indicated on the airport lighting layout plans. The engineer shall indicate specific locations as the work progresses. Ducts shall be of the size, material, and type indicated on the specifications, and shall be installed as shown on the plans. Where

no size is indicated, duct shall be not less than 3 inches inside diameter. All duct lines shall be laid so as to grade toward handholes, manholes, and duct ends for drainage. Grade shall be at least 3 inches per 100 feet. On runs where it is not practicable to maintain the grade all one way, the duct lines shall be graded from the center, both directions, down toward manholes, handholes, or duct ends. Pockets or traps where moisture may accumulate shall be avoided.

The contractor shall mandrel each duct. An iron-shod mandrel, not more than one-quarter ($\frac{1}{4}$) inch smaller than the bore of the duct, shall be pushed through each duct by means of jointed conduit rods. The mandrel shall have a leather or rubber gasket slightly larger than the duct hole.

All ducts installed shall be provided with a No. 10 gauge galvanized iron or steel drag wire for pulling the permanent wiring. Sufficient length shall be left in manholes or handholes to bend the drag wire back to prevent it from slipping back into the duct. Where spare ducts are installed, as indicated on the plans, the open ends shall be plugged with readily removable tapered plugs, designed by the duct manufacturers, or with hardwood plugs conforming accurately to the shape of the duct and having the larger end of the plug at least $\frac{1}{4}$ -inch greater in diameter than the duct.

All ducts shall be securely fastened in place during construction and progress of the work, and shall be plugged to prevent seepage of grout, water, or dirt into them. Any duct section having a defective joint shall not be installed.

Ducts installed under runways, taxiways, aprons, and other paved areas shall be encased in a concrete envelope in accordance with the plans.

Trenches for ducts may be excavated manually or with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed. Road patrols or graders shall not be used to excavate the trench with their blades.

110-3.2 DUCTS ENCASED IN CONCRETE. Unless otherwise shown on plans concrete-encased duct shall be installed so that the top of the concrete envelope is not less than 18 inches below the finished subgrade where installed under runways, taxiways, aprons, or other paved areas, and not less than 18 inches below finished grade where installed in unpaved areas. Ducts under paved areas shall extend at least 3 feet beyond the edges of the pavement or 3 feet beyond any underdrains which may be installed alongside the paved area. Trenches for concrete-encased duct shall be opened the complete length before concrete is laid so that if any obstructions are encountered proper provisions can be made to avoid them. All ducts for concrete encasements shall be placed on a layer of concrete, prior to its initial set, of not less than 3 inches thickness, and thicker where shown on job plans. Where two or more ducts are encased in concrete, the contractor shall space them not less than $1\frac{1}{2}$ inches apart (measured from outside wall to outside wall) using

approved precast concrete spacers. The layer of concrete shall be reasonably straight and even and, prior to placing the duct, shall be tamped to form a level surface. As the duct-laying progresses, concrete not less than 3 inches thick shall be placed around the sides and top of the duct bank with a minimum of $1\frac{1}{2}$ inches of concrete between ducts. End bells shall be installed flush with the concrete encasement where required.

When specified, the contractor shall reinforce the bottom, side, and top of encasements with steel reinforcing mesh or fabric, or other approved metal reinforcement. When directed, the contractor shall supply additional supports where the ground is soft and boggy, where ducts cross under roadways, or wherever otherwise shown on the plans. Under such conditions, the complete duct structure shall be supported on reinforced concrete footings, piers, or piles located at approximately 5-foot intervals.

110-3.3 DUCTS IN TRENCHES. Trenches for single duct lines shall be not less than 6 inches nor more than 12 inches wide, and the trench for two or more ducts installed at the same level shall be proportionately wider. Trench bottoms for ducts without concrete encasement shall be made to conform accurately to grade so as to provide uniform support for the duct along its entire length.

A layer of fine earth material, at least 4 inches thick, loose measurement, shall be placed in the bottom of the trench as bedding for the duct. The bedding material shall consist of soft dirt, sand, or other fine fill, and shall contain no particles that would be retained on a $\frac{1}{4}$ -inch sieve. The bedding material shall be tamped until firm.

Unless otherwise shown on plans, ducts in trenches shall be installed so that the top parts of all ducts are at least 18 inches below the finished subgrade where installed under paved areas, and at least 18 inches below finished grade where installed in unpaved areas.

When two or more ducts are installed in the same trench without concrete encasement, they shall be spaced not less than 2 inches apart (measured from outside wall to outside wall) in a horizontal direction, and not less than 6 inches apart in a vertical direction.

Trenches shall be opened the complete length before duct is installed, so that if any obstructions are encountered, proper provisions can be made to avoid them.

110-3.4 TERRA COTTA DUCTS IN TRENCHES. All terra cotta ducts shall be installed with concrete encasement, as described in Section 3.2. Vitrified clay conduit shall be single-bore type. Where the self-centering socket joint type of single terra cotta duct is used, conduit shall be built up, tier by tier, and separated only by sufficient mortar or fine aggregate concrete to bed the ducts evenly and fill all voids between ducts. Single ducts shall be joined together and the joints grouted with Portland cement mortar. A suitable gasket (of rubber or other approved material) shall first be placed in the female end of the duct, prior to the joining operation, in order to exclude all mortar from the duct holes.

Where the square bore butt-joint type of terra cotta duct, single or multi-cell, is used, sections shall be aligned with at least four steel dowel pins and joints wrapped with duct tape 6 inches wide and lapped 6 inches. All joints shall be staggered, beginning evenly from the manhole or handhole, by means of short lengths 6 inches, 8 inches, 9 inches, 12 inches, and 15 inches long. Cement mortar shall be troweled around each and every joint. Voids in the duct bank, caused by the external shape of the corners of the conduit, shall also be filled with mortar.

110-3.5 DUCT MARKERS. The location of the ends of all ducts shall be marked by a concrete slab marker 2 feet square and 4 inches thick.

The duct markers shall be installed flat in the ground, with approximately 1 inch of the slab projecting above the surface. The markers shall be located immediately above, or slightly to one side, of the ends of all ducts or duct banks, except where ducts terminate in a handhole, manhole, or building.

The contractor shall impress the word "DUCT" on each marker slab. He shall also impress on the slab the number and size of ducts beneath the marker. The letters shall be 4 inches high and 3 inches wide, with width of stroke $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch deep, or as large as the available space permits.

110-3.6 BACKFILLING. After concrete-encased duct has been properly installed and concrete has had time to set, the trench shall be backfilled in at least two layers with excavated material not larger than 4 inches in diameter and thoroughly tamped and compacted to at least ninety (90) percent of maximum density at optimum moisture, as determined by CAA compaction control tests, T-611, for the class of airport involved.

For ducts without concrete envelope, and where one or more than one duct is installed in a trench, 8 inches of sand, soft earth, or other fine fill, loose measurement, shall be placed around the ducts and carefully tamped around and over them with hand tampers. The remaining trench may be filled with regular run of excavated material and thoroughly tamped, as specified, in the paragraph above.

110-3.7 RESTORATION. Any excess excavated material shall be removed and disposed of in accordance with instructions issued by the engineer. After backfilling, the surface shall be left free from ruts and rough spots and restored to its original condition. Where turf is well established and the sod can be moved, it shall be carefully stripped, properly stored, and replaced as soon as possible after backfilling is completed. Where turfing work has been done, but where the turf is not established, the lighting contractor shall restore to its original condition all areas disturbed by the trenching, storage of dirt, and duct installation. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, topsoil planting, or mulching. The work shall be performed in accordance with CAA Standard Turfing Specifications, as directed by the engineer. The

contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance.

METHOD OF MEASUREMENT

110-4.1 The quantity of underground duct to be paid for under this item shall be the number of linear feet of duct installed, measured in place, completed, and accepted.

BASIS OF PAYMENT

110-5.1 The linear feet of underground duct measured, as provided above, shall be paid for at the contract unit price for each linear foot of runs of single-, two-, three-, four-, six-, or eight-way sections encased in concrete; encased in reinforced concrete; or without concrete encasement, installed in place, and accepted. This price and payment shall constitute full compensation for furnishing and placing all material; for all trenching, including excavation, installation of duct, backfill, reconditioning, for mandreling; for furnishing of concrete and reinforcement, if required; for removing and restoring of any paved area; for installation of all duct markers and steel drag wires; for end bells and caps and miscellaneous fittings; for disposal of surplus materials; for maintenance of disturbed areas; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Item L-110-5.1 Airport Underground Electrical Duct—per linear
Payment will be made under:

foot.

ITEM L-111 INSTALLATION OF AIRPORT BUILDING WIRING

DESCRIPTION

111-1.1 This item shall consist of a complete system of building wiring including light, power signal, and control wiring installed in accordance with this specification and in conformity with design wiring diagrams and dimensions shown on the plans. This work shall include installation of conduit outlet boxes, duct, wire and cable, fixtures, lamps, switches, painting, tagging, labeling equipment, and testing of the system as a completed unit, to the satisfaction of the engineer, and ready for operation.

MATERIALS

111-2.1 CONDUIT. Rigid steel conduit and fittings shall conform to requirements of Federal Specification WW-C-581.

111-2.2 TUBING. Electrical metallic tubing and fittings shall conform to the requirements of Federal Specification WW-T-806.

111-2.3 OUTLET BOXES. All outlet boxes shall be of sufficient size to enclose the devices mounted therein, and shall have ample space for wiring.

(a) Ceiling and wall-flush-type outlet boxes shall conform to Federal Specification W-O-821 for "Outlet Boxes; Steel, Cadmium, or Zinc-coated with Covers and Accessories."

(b) Exposed outlet boxes or conduit fittings shall be cast or malleable iron fittings conforming to Federal Specification W-O-806. Outlet boxes or fittings exposed to weather shall be watertight with threaded hubs.

111-2.4 JUNCTION AND PULL BOXES. Junction and pull boxes shall be of No. 10 U. S. Standard gauge steel for boxes 12 inches x 12 inches or larger, and No. 12 gauge for boxes smaller than 12 inches x 12 inches. Boxes shall not be smaller than sizes indicated on drawings or required by the National Electrical Code. The covers for these boxes shall be of the same gauge as the box with which they are assembled, and shall be securely held by eight or more round-head brass machine screws spaced not over 12 inches apart. These boxes shall be designed for the specified purpose for which they are to be used, and shall be drilled only for the number of conduits required.

111-2.5 WIRE. Wire shall conform to Federal Specification J-C-103, Type R or RH, for use up to 5,000-volt service, and shall

be of the size, number of conductors, and service voltage called for on the plans. In no case shall wire smaller than No. 12 be used except for control wires, which shall be No. 14, unless otherwise indicated on the drawings. Each coil or reel shall be distinguished by approved underwriters tag giving manufacturer's name, date of manufacture, and maximum voltage. Unless otherwise specified, conductors larger than No. 8 shall have standard commercial stranding.

111-2.6 TAPES. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Varnished cambric insulating tape shall conform to A. S. T. M. Designation D-373.

(c) Friction tape shall conform to Federal Specification HH-T-101.

111-2.7 SWITCHES, FIXTURES AND RECEPTACLES. Ceiling and wall fixtures, switches, and receptacles shall be as specified on the plans or in the specifications, and shall be in conformity with the National Electrical Code and bear an Underwriters label.

CONSTRUCTION METHODS

111-3.1 GENERAL. The contractor shall conform to the applicable requirements of State, county, and city laws and ordinances. He shall comply with the rules and regulations of the code requirements of the county, city, or town in which the airport is located, or with the requirements of the National Electrical Code of the National Board of Fire Underwriters where no local code applies.

111-3.2 RIGID STEEL CONDUIT. Installation of conduit for light, power, and control purposes shall conform to the location, and shall be exposed or concealed, as indicated on the plans. The conduit system shall be continuous from outlet to outlet or fitting to fitting so that electrical continuity is obtained between all conduits of the system.

Ends of all conduit shall be cut square, and inner edges reamed. Adjoining lengths shall butt together evenly in the couplings to provide passage for installing conductors.

Pockets or traps where moisture may collect in conduit runs shall be avoided. Where practical, conduits from brackets and switches shall be run up to the ceiling, rather than down to the floor, in order to prevent the accumulation of condensation.

Conduits shall be of ample size to allow drawing in or removing of wires and cables without undue strain, and suitable chafing bushings shall be installed on each end of every run of conduit where wires are installed. Where necessary, powdered soapstone shall be used as a lubricant for drawing wires through conduit. No other means of lubricating will be allowed.

Conduit shall be installed entirely free from other piping, valves, or mechanical equipment, and shall not be installed nearer than 6 inches to hot-water pipes, steam pipes, and heating flues.

Bends, offsets, and crossing of conduits shall be avoided wherever possible. When bends and offsets are necessary, they shall be made with an approved hickey or a conduit-bending machine. The use of a vise or pipe tee will not be permitted. Bends shall be made so that the interior cross-sectional area will not be reduced. The radius of the curve of the inner edge of any field bend shall not be less than ten times the internal diameter of the conduit. A run of conduit between outlet or other boxes shall not include more than the equivalent of two 90° angle bends, including those bends located immediately at the outlet or fitting. The use of running threads will not be permitted. Where conduits cannot be joined by standard-threaded couplings, approved watertight conduit unions shall be used.

Conduits shall be capped during construction with metal-capped bushings to prevent the entrance of dirt or moisture. All conduits shall be thoroughly swabbed out and dried before wires or cables are pulled in.

Fish wires, cords, strings, chains, or the like shall not be placed or inserted in the conduit system during installation.

After the conduit system has been installed and thoroughly dried out, the empty conduits shall be left with a No. 14 galvanized iron drag wire.

Conduit shall be securely fastened in place to all outlet boxes and to the structure or support. It shall be securely fastened to the outlet boxes with galvanized double locknuts and bushings of first-grade manufacture. An adequate number of conduit threads shall project through the box for bushings. Anchorage for 1½ inches and smaller conduit shall be made with the two-hole galvanized conduit strap or clamp; 2 inches and larger conduit shall be anchored with galvanized wrought iron "U" clamps.

Exposed conduit shall be installed parallel with, or at right angles to, building structures, walls, floors, and ceilings. All exposed conduits shall be securely fastened in place with one-hole galvanized pipe clamps and substantial screws in lead expansion shields spaced not more than 5 feet apart; or with approved beam clamps or approved single or gang pipe hangers spaced not more than 10 feet apart, as the conditions require. Vertical runs of conduit shall be supported at intervals not exceeding 10 feet by approved clamp hangers.

Where conduit crosses under ceiling building beams, it may be run straight from beam to beam, except that it shall be firmly supported between beams with suitable galvanized iron rod pipe hangers spaced not more than 10 feet apart.

Special steel frames or brackets for supported conduit shall be used as required. After installation, they shall be painted with best grade aluminum paint, or as directed by the engineer.

Concealed conduit to be laid in concrete slabs, behind wall furring, above false ceilings, in special riser chases and shafts, or underground, shall be installed as the building construction or work progresses. All

J-C-103, Type R shall be installed in concrete slabs, walls, floors, and ceilings.

underground conduit shall be painted with approved bituminous compound.

Conduit in concrete slab floor shall be kept as low as possible and not less than 1 inch below the finished floor line or top finish surface line. Care shall be taken to avoid crossing more than two conduits at any one point unless space provided permits, and conduits shall be run accordingly. Where it is necessary to run conduits through a slab, sleeves shall be provided for this purpose. No cutting of the concrete will be permitted after the concrete is poured.

When making threaded conduit joints underground, in concrete, or exposed to weather, the threads shall be first coated with red lead and immediately screwed together. All such joints shall be made watertight. All abrasions of coating shall be painted with approved moisture-proof paint.

Where conduits are installed in floor fill or slab crossing building expansion joints, approved conduit expansion joints shall be used of the watertight, vaporproof, slip-joint type, with metallic packed slip joint to provide for a conduit movement of 2 inches minimum. Expansion joints shall each have a copper strap ground jumper with copper clamps.

All conduit which is deformed or crushed in any way shall be removed from the job at once.

111-3.3 ELECTRICAL METALLIC TUBING. Connections between outlets where run in hung ceilings of buildings, or exposed conduit runs, may be made with electrical metallic tubing in lieu of rigid conduit. All connectors shall be securely tightened.

111-3.4 CEILING AND WALL OUTLET BOXES. Each fixture, extension, switch, and receptacle outlet, and each telephone and signal outlet shown on airport building lighting plans shall be provided with an outlet box. Outlets set in plastered ceilings or walls shall have plaster ring covers.

Where boxes are exposed to the weather, approved watertight conduit fittings with threaded hubs shall be used. Where outlets occur in hazardous locations, such as in doping and paint rooms, explosionproof fittings with threaded hubs shall be installed.

Standard deep-type concrete outlet boxes, not more than 6 inches deep, shall, where conduits enter at the sides, be used in order to avoid steel reinforcing rods.

Boxes for ceiling and interior bracket lighting fixtures shall have $\frac{3}{8}$ -inch malleable iron fixture studs. All studs shall be in centers of boxes and shall be secured by not less than three stove bolts each, or other construction equivalent in strength. Nuts shall be drawn up tight and threads upset.

Outlet boxes for ceiling and bracket fixtures, where conduit is concealed, shall be deep-type boxes not less than 4 inches in diameter by $1\frac{1}{2}$ inches deep without covers, or suitable modification approved by the engineer in charge. All ceiling outlets shall have ears and screws

for devices or blank covers. Outlet boxes for fixtures, where conduit is exposed, shall be screw-jointed "P" series conduit fittings not less than 6 inches in diameter, and shall provide a seat for lighting canopy.

Outlet boxes for lamp receptacles inside building shall be similar to bracket outlet boxes, but shall have covers to accommodate the lamp receptacles specified.

Outlet boxes for lamp receptacles at exterior locations shall be cast iron, screw-jointed, weatherproof-type of proper design to accommodate the lamp receptacle.

Outlet boxes for switches and plug receptacles in finished walls shall be of proper design to accommodate the switches, receptacles, and conduits required at each location, and provide ample room for connections. They shall have covers with rectangular openings of proper size and shape.

Outlet boxes for telephone and signal wall outlets shall be 4 inches square, and shall have covers with rectangular openings in center. Each such outlet shall have a plate with $\frac{3}{8}$ -inch bushed opening in center, and finished same as switch and receptacle plates.

Telephone outlets in office spaces shall be set flush in the wall just above baseboard, unless otherwise noted or specified. Where telephone outlet is for wall type instrument, it shall be located 4 feet 9 inches above the floor.

In installation, all outlet boxes shall be rigidly secured in position. All boxes shall be set so that the front end of the box or cover shall be flush with the finished wall or ceiling line, except on unfinished ceilings and walls, extension outlets, and where conduits are run exposed. Where a ceiling outlet is shown, and drop beam occurs, the outlet shall be set with its center at least 9 inches from the finished edge of the beam, unless noted otherwise on the building lighting plans.

At the point of installation all outlet boxes shall have only the holes necessary to accommodate the conduits. All boxes shall have lugs or ears inside to secure covers.

111-3.5 JUNCTION AND PULL BOXES. The boxes shall be framed together with small angles or welded. The box, cover, and reinforcing angles shall be aluminum painted after fabrication. Each pull or junction box installed shall be suitably identified. The system served shall be distinctly and neatly stenciled in an approved manner on the box cover.

The contractor shall install pull boxes where necessary in approved locations and in feeder conduits as follows, unless otherwise shown or specified on the airport lighting plans:

Straight runs shall not exceed 150 feet without a pull box.

Runs with one 90° bend or equivalent shall not exceed 100 feet without a pull box.

Runs with two 90° bends or equivalent shall not exceed 75 feet without a pull box.

111-3.6 WIRING. The contractor shall run all wires in rigid steel conduit or electrical metallic tubing. Armored cable shall be used only for short flexible connections to motors or other equipment.

The number and size of insulated wires installed in single conduits, and the current-carrying capacity of each, shall be in accordance with the National Electrical Code.

Color code wires shall be used throughout for all light, power, and signal systems. Where a four-wire, three-phase, distribution system is used, the following code should be employed: white for neutral, black for Phase "A," red for Phase "B," and yellow for Phase "C."

Wires shall be of sizes shown on drawings. No wire smaller than No. 12 B & S gauge shall be used for light or power circuits.

All branch circuit wiring shall be No. 12 B & S gauge, unless otherwise specified on the plans.

Loops of not less than 8 inches shall be left at all outlets for connections to fixtures. Exposed wires in distribution panels shall be neatly and symmetrically arranged with multiple wires taped to form a cable in boxes. Frayed ends of wires and conductors at panels, motors, etc., shall be taped.

Circuit and feed wires and cable shall be continuous from switch to terminal or outlet and between junction and pull boxes. Joints or splices in conductors shall be made only in junction or pull boxes, outlets, switch boxes, or at panels. These joints shall be carefully soldered, well insulated with rubber, properly taped to build up insulation equal to that on wire and cable, and then painted with an insulating compound.

All wire and cable installed in permanently moist locations, where condensation and accumulation of moisture in the conduit is likely to occur, shall be either lead covered or approved Type RW wire or Type SN wire. Moist locations shall include wire installed below finished floors, where the floor slab is in direct contact with the earth; wire installed in outside building walls, which are below the level of the finished grade; and other similar locations.

111-3.7 GROUNDING. Each entire conduit system shall be grounded to the main cold water service pipe at the point of entrance inside the building, using approved grounding fittings. Where there is no cold water pipe in the building the contractor shall furnish and install at least two artificial grounding electrodes outside the building. Grounding conductors shall be the same kind and size as the other building wire specified. The grounding conductors shall be run in rigid conduit, and shall be securely bonded to conduit at entrance and exit. All grounding shall conform to the requirements of Article 250 of the National Electrical Code, and/or the local code agency having jurisdiction.

111-3.8 TESTING. The building wiring installation shall be tested in operation as a completed system prior to acceptance. Tests shall include megger, voltage, and ground-resistance readings.

The resistance to ground shall not be less than the values shown below:

Conductor size	Resistance to Ground
No. 14 or No. 12-----	1,000,000 ohms
No. 10 or No. 8-----	250,000 ohms
No. 6 or No. 4-----	100,000 ohms

- a. The above values shall be determined with all switchboards, panel boards, fuseholders, switches, and overcurrent devices in place.
- b. If lampholders, receptacles, fixtures, or appliances are also connected, the minimum resistance permitted for branch circuits supplying same shall be one-half ($\frac{1}{2}$) the values specified in the table above.

Testing equipment shall be furnished by the contractor. Tests shall be conducted in the presence of the engineer and shall be to his satisfaction. The contractor shall furnish the engineer three certified copies of all test reports made.

METHOD OF MEASUREMENT

111-4.1 The quantity of wiring to be paid for under this item shall be the number of complete systems installed in place, ready for operation, and accepted.

BASIS OF PAYMENT

111-5.1 Payment for wiring shall be at the contract unit price for one complete job in place and accepted, which price and payment shall constitute full compensation for all conduit and fittings; for all electrical metallic tubing; for all ceiling and wall outlet boxes; for all junction and pull boxes; for all wiring; for grounding and testing; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-111-5.1 Airport Building Wiring, in Place—per unit job.

ITEM L-112 INSTALLATION OF AIRPORT WIND TEE

DESCRIPTION

112-1.1 This item shall consist of an airport wind tee furnished and installed in accordance with this specification at the location and in conformity with the design and dimensions shown on the plans. The work shall include the mounting, leveling, servicing, wiring, painting, and testing of the wind tee and all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the engineer.

MATERIALS

112-2.1 WIND TEE. The tee shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-808, "Lighted Wind Tee."

112-2.2 WIRE. Wire shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage shown on the plans or proposal.

112-2.3 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

112-2.4 CONCRETE. The concrete for the base shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete," using a $\frac{3}{4}$ -inch maximum size coarse aggregate.

112-2.5 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed type bars and shall meet the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

112-2.6 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages bearing the maker's name and brand designation. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil----- JJJ-O-336

Turpentine, Type 1----- LLL-T-791

Dryer; Paint, Liquid, Type A----- TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint conforming to Federal Specification

TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) Chrome-yellow paint for body and finish coats on metal and wood surfaces shall conform to Federal Specification TT-P-53. (Yellow No. 120, color card supplement to U. S. Army Specification 3-1.)

(d) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified chrome-yellow paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

CONSTRUCTION METHODS

112-3.1 CONCRETE PEDESTAL. The wind tee shall be mounted on a concrete pedestal at the location shown on the plans. The concrete shall be poured in place and shall rest on undisturbed soil.

The pedestal shall be reinforced by steel bars formed and placed as indicated on the plans. The exposed concrete surface shall be finished smooth with a steel trowel or rubbed to a smooth finish.

112-3.2 MOUNTING. Before fastening the wind tee base to the concrete pedestal, the mounting holes shall be checked for correct spacing. Base or legs shall not be strained or forced out of position to fit incorrect spacing of mounting holes. The wind tee shall be assembled and mounted in accordance with the manufacturer's installation instructions. The under surface of the wind tee, when mounted on its pedestal, shall be not less than 4 feet above ground level.

112-3.3 LEVELING. After the wind tee has been mounted in place it shall be accurately leveled and, if necessary, counterbalanced to the satisfaction of the engineer.

112-3.4 SERVICING. Before placing the wind tee in operation, the contractor shall accomplish the following:

- a. Clean interior of base and check for alignment of parts.
- b. Clean and polish slip rings. Apply a very small amount of vaseline to the slip rings and wipe surplus off the rings.
- c. Set brushes for free motion on slip rings and adjust springs to proper pressure.

112-3.5 WIRING. The contractor shall furnish all necessary labor and materials and shall make complete above-ground connections to the power supply cable and all internal connections for the operation of the lights on the wind tee.

The underground cable for the power feed from the transformer vault to the wind tee site and duct, if required for this cable installation under paved areas, shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable," and Item L-110, "Installation of Underground Duct."

112-3.6 CONDUIT. All exposed wiring or cable shall be run in not less than one (1) inch rigid steel conduit. The conduit for

the power supply shall be brought through the concrete pedestal and shall connect to the base as indicated on the plans. The underground section of the conduit shall terminate in a bushing to protect the supply cable. The underground cable may be installed in conduits above ground.

112-3.7 BOOSTER TRANSFORMER. When specified, a booster transformer shall be installed in a suitable weatherproof housing near the wind tee, as indicated on the plans and described on the proposal.

If a booster transformer for the wind tee is required to be installed in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

112-3.8 PAINTING. The specifications covering the wind tee and base require that these be painted by the manufacturer. However, the contractor shall be responsible for cleaning any rusted or bare surfaces and painting them with a prime and two finish coats to match the original finish. All other exposed equipment (except the concrete pedestal) shall be given one prime and one finish coat of chrome-yellow paint after erection.

112-3.9 TESTING. The installation shall be fully tested in operation as a completed unit prior to acceptance. These tests shall include balance and operation of the tee, and voltage readings. Any necessary test equipment shall be furnished by the contractor. Tests shall be conducted in the presence of the engineer and shall be to his satisfaction.

METHOD OF MEASUREMENT

112-4.1 The quantity of wind tees to be paid for under this item shall be the number of wind tees installed as completed units in place; ready for operation, and accepted.

BASIS OF PAYMENT

112-5.1 Payment for wind tees shall be the contract unit price for each complete job with all necessary materials furnished in place by the contractor and accepted by the engineer, which price and payment shall constitute full compensation for the furnishing, mounting, leveling, servicing, and adjusting of the wind tee; for furnishing and installing the concrete pedestal; and all electrical connections, including wiring, conduit and fittings; for painting the wind tee, if necessary, and painting all material installed under this item; for furnishing and installing a booster transformer, if specified; and for all labor, equipment, tools, tests, and testing equipment necessary to complete this item.

Payment will be made under:

Item L-112-5.1 Installation of Wind Tees—per each.

ITEM L-113 INSTALLATION OF AIRPORT ROTATING BEACON FOR SMALL AIRPORTS

DESCRIPTION

113-1.1 This item shall consist of a small airport beacon, furnished and installed in accordance with this specification at the location and in conformity with the design and dimensions shown on the plans. This work shall include the mounting, leveling, servicing, wiring, painting, and testing of the beacon and all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the engineer. This item shall include a mounting platform and/or a booster transformer if stipulated on the plans.

MATERIALS

113-2.1 BEACON. The beacon shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-801, "Beacon for Small Airports."

113-2.2 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH and shall be of the size, number of conductors and service voltage shown on the plans or proposal.

113-2.3 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

113-2.4 PAINT. (a) Red lead priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to the 95-percent grade Federal Specification TT-R-191. The red lead shall be furnished in paste form and delivered on the job in the original unbroken packages, bearing the maker's name and brand designation. The raw linseed oil, turpentine, and drier shall be in accordance with the Federal Specifications listed below:

Raw Linseed Oil.....	JJJ-O-336
Turpentine, Type 1.....	LLL-T-791
Drier; Paint, Liquid, Type A.....	TT-D-651

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide primer paint conforming to Federal Specification TT-P-641, Class A. If necessary, add not more than one-half ($\frac{1}{2}$) pint of turpentine to the gallon.

(c) Chrome-yellow paint for body and finish coats on metal and wood surfaces shall conform to Federal Specification TT-P-53. (Yel-

low No. 120, color card supplement to U. S. Army Specification 3-1.)

(d) White paint for body and finish coats on metal and wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) International-Orange paint for body and finish coats on metal and wood surfaces shall consist of a ready-mixed, bright, nonfading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of Federal Specification TT-P-59, Type B.

CONSTRUCTION METHODS

113-3.1 PLACING THE BEACON. The beacon shall be mounted on a pole, beacon tower, platform, or building roof, as shown on the plans.

113-3.2 MOUNTING. Before fastening the beacon to the mounting platform, the mounting holes shall be checked for correct spacing. Beacon base or mounting legs shall not be strained or forced out of position to fit incorrect spacing of mounting holes.

113-3.3 LEVELING. After the beacon has been mounted in place it shall be accurately leveled to the satisfaction of the engineer.

113-3.4 SERVICING. Before placing the beacon in operation the contractor shall accomplish the following:

- a. Clean and polish all glassware both inside and outside, using a type of cleaner which will not scratch the lens, and clean the interior of beacon.
- b. Clean interior of beacon base and check for alignment of parts.
- c. Clean and polish slip rings. Apply a very small amount of vaseline to the slip rings, operate about one-half ($\frac{1}{2}$) hour, then wipe surplus off rings. Remove the brushes and lubricate the chamber of the brush holders.
- d. Grease gears of rotating mechanism and check meshing where gears are accessible. The beacon shall be oiled and greased to conform to the manufacturer's recommendations.
- e. Set brushes for free motion on slip rings and adjust springs to correct pressure to provide firm contact.
- f. Lamps shall be properly secured in the sockets.

113-3.5 ADJUSTMENT OF BEAM. After the beacon has been mounted and leveled, the elevation of the beams shall be adjusted. The final beam adjustments shall be made at night so that results can be readily observed. The beams shall be set for a 6-degree elevation unless otherwise shown on the plans or directed by the engineer.

113-3.6 BEACON MOUNTING PLATFORM. Where the beacon is to be mounted at a location where a mounting platform is required, the construction of this mounting platform and any necessary lightning-protection equipment shall be in accordance with the details

shown on the plans. If required, the supporting pole or tower shall be considered part of the platform.

113-3.7 WIRING. The contractor shall furnish all necessary labor and materials and shall make complete above-ground electrical connections in accordance with the wiring diagram furnished with the project plans, or in accordance with the wiring diagram furnished by the manufacturer of the beacon.

If underground cable for the power feed from the transformer vault to the beacon site is required, the cable shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable for Large Airports," or in accordance with (and paid for by linear foot measurement as described in) Item L-118, "Installation of Airport Underground Cable for Small Airports," as stipulated in the proposal.

113-3.8 CONDUIT. All exposed wiring shall be run in not less than 1-inch galvanized rigid steel conduit. No conduit shall be laid on top of a beacon platform floor. If mounted on steel beacon tower, the conduit enclosing the beacon wiring shall be fastened to the tower members with "Wraplock" straps, clamps, or approved fasteners, spaced approximately five (5) feet apart. Conduit shall be attached to wooden structures with galvanized pipe straps and fastened with galvanized wood screws not smaller than No. 8 or less than 1¼ inches long. There shall be at least two fastenings to each 10-foot length. If an obstruction light is to be installed near the beacon and energized from the same circuit, a conduit tee connection shall be installed near the beacon.

113-3.9 BOOSTER TRANSFORMER. When specified, a booster transformer to compensate for voltage drop to the beacon shall be installed in a suitable weatherproof housing under or on the tower platform, or shall be installed at the base of the tower, as indicated on the plans and described in the proposal. If this booster transformer is required to be installed in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

113-3.10 PAINTING. If the construction of a wooden mounting platform is stipulated in the proposal as part of this item, all wooden parts of the platform shall be given one priming coat of white or International-Orange paint after fabrication but before erection and one body and one finish coat of International-Orange paint after erection. Steel mounting platforms shall be given one priming coat of red lead before erection, and one body and one finish coat of International-Orange paint after erection. All equipment installed under this contract and exposed to the weather shall be given one body and one finish coat of International-Orange paint. This shall include beacon (except glass surfaces), beacon base, all conduit and transformer cases. It shall not include lightning rods nor obstruction light globes.

All surfaces shall be prepared for painting by cleaning. The surfaces shall be dry and free from scale, grease, rust, dust, and dirt when paint is applied. All knots in wood surfaces shall be killed with shellac immediately before applying the priming coat of paint. Nail holes and permissible imperfections shall be filled with putty.

The ready-mixed paint shall be thinned for the priming and body coats in accordance with the manufacturer's recommendations. In the absence of such recommendations, the following shall apply:

Body Coats (for both wood and steel surfaces): Add one-half ($\frac{1}{2}$) pint of turpentine to each gallon of ready-mixed paint for body coats.

Finish Coats (for both wood and steel surfaces): The ready-mixed paint shall be used as it comes from the container for finish coats.

113-3.11 TESTING. The installation shall be fully tested in operation as a completed unit prior to acceptance and these tests shall include lamp-changer operation, megger and voltage readings. The resistance to ground of the beacon supply circuit shall be not less than 100,000 ohms. Testing equipment shall be furnished by the contractor.

METHOD OF MEASUREMENT

113-4.1 The quantity of beacons to be paid for under this item shall be the number of beacons installed as completed units in place, ready for operation, and accepted.

BASIS OF PAYMENT

113-5.1 Payment for beacons shall be at the contract unit price for each complete job with all necessary materials furnished in place by the contractor and accepted by the engineer, which price and payment shall constitute full compensation for the furnishing, mounting, leveling, servicing, and adjusting of the beacon; for furnishing and installing all electrical connections, including wiring, conduit, and fittings; for painting all material installed under this item; for furnishing and installing a booster transformer, if specified; for furnishing, fabricating, and erecting a beacon mounting platform, including support and lightning protection, if specified; and for all labor, equipment, tools, tests, and testing equipment necessary to complete this item.

Payment will be made under:

Item L-113-5.1 Installation of Rotating Beacon for Small Air ports—per each.

ITEM L-114 INSTALLATION OF AIRPORT ELEVATED MARKER LIGHTS, BASE-MOUNTED TYPE

DESCRIPTION

114-1.1 This item shall consist of elevated marker lights, for series or multiple circuits, base-mounted type with concrete pad, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. This item shall include the furnishing and installing of concrete pads for mounting the light units, of conduit lead-ins, of transformers, and lamps. This item shall also include all cable connections, the testing of the installation, and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

114-2.1 ELEVATED MARKER LIGHT. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, as conforming to the requirements of Specification L-802, "Specification for Elevated Runway and Strip Marker Lights," and shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with lens assembly of the color specified in the proposal, fitting, cone, base-mounting assembly, transformer, and a base. The type of base shall be specified in the proposal and shall conform to one of the following:

- a.* Shallow base assembly, Type AN-2513, complete with bolts, gasket, and cover.
- b.* Deep base assembly, Type AN-2509, complete with bolts, gasket, and cover.
- c.* Base assembly, as shown in the proposal, complete with bolts, gasket, and cover. The base flange shall provide mounting dimensions interchangeable with bases Type AN-2513 and AN-2509.

114-2.2 TAPE. (*a*) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(*b*) Friction tape shall conform to Federal Specification HH-T-101.

114-2.3 CONCRETE. The concrete for pads or manholes shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

114-2.4 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed bars, and shall meet the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

114-2.5 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

114-2.6 CABLE SQUEEZE CONNECTORS. Squeeze connectors shall be similar and equal to Crouse-Hinds Type CGB cable connector with neoprene rubber bushing of maximum durometer hardness of 40.

114-2.7 TEES. Large radius bend tees shall be similar and equal to Crouse-Hinds No. ET-43.

CONSTRUCTION METHODS

114-3.1 PLACING THE LIGHTS. The elevated marker lights shall be installed at the approximate locations shown on the plans. The exact location shall be as directed by the engineer in charge.

114-3.2 CONCRETE PAD. The elevated marker light bases shall be installed in concrete pads approximately four (4) feet square or four (4) feet in diameter, made and formed in accordance with the details shown on the plans. The concrete pad shall not be prefabricated but shall be poured in place and shall rest on undisturbed soil. It shall be reinforced with steel bars formed and placed as indicated on the plans. The exposed concrete surface shall be finished smooth with a steel trowel or rubbed to a smooth finish. After the concrete has set sufficiently the contractor shall remove the construction support and forms, clean out any debris which may be in the base, and install the plywood cover. The contractor shall install the permanent base cover and the elevated light after wiring connections have been made, as described hereafter.

114-3.3 LEVELING. The marker light base shall be adjusted and firmly held in place so that the machined upper surface of the base flange will extend $\frac{1}{4}$ inch above the surface of the concrete pad. The base flange shall be level within plus or minus 2 degrees.

114-3.4 IDENTIFICATION NUMBER. The contractor shall impress an identifying number on the top surface of the concrete pad on the side nearest and parallel to the runway centerline. The number shall be approximately 4 inches high, 3 inches wide, and $\frac{1}{2}$ -inch stroke. The numbers shall correspond with the numbers indicated on the lighting plan or as designated by the engineer.

114-3.5 CABLE ENTRANCE. Cable will be installed between the marker light units as a separate item, and the contractor shall bring this cable into the elevated light bases as shown on the plans.

114-3.6 CABLE CONNECTIONS. In making cable connections to the elevated lights, the contractor shall pull cables into each light base and shall leave sufficient slack cable inside the base to

permit connections to be made to the transformer primary terminals when the transformer is removed from the base.

The insulation shall be removed from the conductor ends without nicking the conductor. Exposed conductors shall then be prepared and connected to the transformer primary terminals, as directed in the manufacturer's installation instructions. The secondary terminals shall be prepared and connected to the lamp leads, as described in the following paragraph 3.7. After the cable is connected, the bushings shall be drawn up tightly on the rubber jacket of the primary and secondary cables. The contractor shall ascertain that the rubber bushing inserts are of correct size for all cable. Incorrect sizes shall be replaced. The transformer shall be placed in the base and excess cable arranged so that the transformer may be readily withdrawn for inspection.

When a bare neutral is used, this shall be connected as described in the manufacturer's installation instructions.

114-3.7 ASSEMBLING THE UNIT. The elevated marker light shall be assembled in accordance with the manufacturer's installation instructions. The transformer secondary shall be connected to the lamp leads by means of the disconnecting plug and receptacle provided with the unit, *and this joint shall not be taped*. If necessary, a splice may be made between the receptacle and the transformer. If required, this splice shall be made in accordance with Paragraph 3.4 (b) of Item L-115. A lamp of the proper rating shall be installed in the fixture. The distance from finished grade to the top of the fixture shall be as indicated on the plans but, in any event, shall not exceed 30 inches.

114-3.8 LEVELING AND BEAM ADJUSTMENT. The optical system shall be leveled to within 1 degree. Leveling shall be accomplished as recommended by the manufacturer.

After leveling, the contractor shall adjust the asymmetric lens of each optical system so that the two concentrated beams of light shine up and down the runway or taxiway and are "toed-in" symmetrically toward the centerline. The contractor shall be held responsible for correct leveling, adjustment, and orientation of all elevated lights installed by him. Final adjustment of the asymmetric lenses shall be made at night and shall be to the satisfaction of the engineer.

114-3.9 TESTS. If required in the proposal, the cable connection to each elevated light shall be tested for insulation resistance. The testing procedure shall be in accordance with the applicable provisions of Item L-108, "Installation of Underground Cable for Large Airports," or as directed by the engineer.

METHOD OF MEASUREMENT

114-4.1 The quantity of lights to be paid for under this item shall be the number of each type of elevated marker lights installed

as completed units in place, ready for operation, and accepted by the engineer.

BASIS OF PAYMENT

114-5.1 Payment for lights shall be made at the contract unit price for each complete elevated marker light installed in place and accepted by the engineer, which price and payment shall constitute full compensation for furnishing and installing the elevated marker light, including transformer and base assembly; for furnishing and installing the concrete pad; for leveling the base; for impressing identifying numbers on the concrete pad; for furnishing and installing rigid steel conduit lead-ins and necessary fittings for the cable entrance; for furnishing and installing the lamp; for making all cable connections to the transformer and fixture; for adjusting the light beam; for testing and furnishing all testing equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-114-5.1 Installation of Airport Elevated Marker Lights for Series or Multiple Circuits, Base-Mounted Type With Concrete Pad—per each.

ITEM L-115 INSTALLATION OF AIRPORT ELEVATED MARKER LIGHTS, STAKE-MOUNTED TYPE

DESCRIPTION

115-1.1 This item shall consist of elevated marker lights, for 600-volt series or multiple circuits, stake-mounted type, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installing of transformers or junction boxes. This item shall also include all cable connections, furnishing and installing of all lamps, the testing of the installation, and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

115-2.1 ELEVATED MARKER LIGHTS. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification No. L-802, "Specification for Elevated Runway and Strip Marker Light," and shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fitting, cone, stake mounting assembly, and transformer or junction box.

115-2.2 TAPE. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Friction tape shall conform to Federal Specification HH-T-101.

CONSTRUCTION METHODS

115-3.1 PLACING THE LIGHTS. The elevated lights shall be installed at the approximate locations shown on the plans. The exact location shall be as directed by the engineer in charge.

115-3.2 TRANSFORMER INSTALLATION. If a transformer or junction box is required for the operation of the elevated light, it shall be installed by one of the following methods:

(a) *Series Transformers.* The transformer shall be buried directly in the earth. The top shall be not less than 14 inches below ground level and the leads shall be located at the bottom. Connections shall be made as described in Paragraph 3.4 as required.

After connections are made, the bedding material shall be laid, the transformer placed in the hole of trench and backfill begun. All bedding and backfill material shall be either earth or sand containing no particles that would be retained on a 1-inch sieve. The layer of bedding under the transformer shall be 3 inches thick, loose measurement.

The secondary lead shall be laid underground from the transformer to the center of the marker light, at which point it shall be brought out of the ground. All backfill material shall be thoroughly tamped and compacted. If necessary to obtain compaction, the backfill material shall be moistened or aerated as required.

(b) *Multiple Transformers.* Multiple transformers or junction boxes shall be placed in the earth with the cover accessible at ground level for replacement of fuses. Backfill and compaction shall be made in accordance with Paragraph 3.2 (a). Assembly shall be made in accordance with the manufacturer's installation instructions.

115-3.3 STAKES. The cone shall be supported by three stakes which shall be driven vertically and equidistantly spaced on a circle slightly larger than the circumference of the cone. If templates for driving these stakes are not provided by the manufacturer of the lighting unit a template shall be made for this purpose. Stakes shall be driven to a depth of at least 9 inches and shall be located so that the cone is firmly supported by the clips or slots in the stakes. Stakes shall be driven in undisturbed soil or in compacted backfill. Stakes shall not be driven directly over the transformer or its primary or secondary leads or the underground supply cable. Leveling shall be accomplished with the cone in place and shall be accurate within 3 degrees.

115-3.4 CABLE ENTRANCE AND CONNECTIONS. Underground cable will be installed between the units as a separate item and the contractor shall connect this cable to the transformer, junction box, or elevated light. The connection to the underground cable supply shall be made by one of the following methods:

(a) *Plug and Receptacle Connection.* The plug and receptacle shall first be cleaned. A single band of rubber tape shall be placed around the joined plug and receptacle. The ends of the tape shall butt cleanly. The surface of the plug and receptacle and the tape band shall be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying covering tape. The joint shall then be wrapped with a layer of rubber tape which shall be applied tightly and shall be half lapped, extending at least 1½ inches each side of the joint. One layer of friction tape shall then be added. This layer shall be half lapped and shall completely cover the rubber tape. Wraps shall be essentially smooth and compact.

(b) *Spliced Connection.* Leads shall be prepared for splicing by removing adequate insulation and jacket to permit the type of splice being made. If the cable has a filler between insulation and jacket, the jacket shall be cut back to expose at least 1 inch of insulation, and care shall be taken not to cut into cable insulation. The ends of the insulation on each conductor shall be penciled down. Fillers, if used, shall be cut off flush with the jacket. Bare wire shall be made bright and clean for all types of splices.

Western Union splices or solderless connectors of the proper size for the conductor shall be used. The contractor shall install the solderless connector or make a Western Union joint which is mechanically and electrically secure. The Western Union joint shall be soldered and care shall be taken not to burn the insulation. A noncorrosive paste flux shall be used for all soldered joints.

Each conductor shall be covered with rubber tape to approximately one and one-half ($1\frac{1}{2}$) times the thickness of the original insulation. The rubber tape shall be tightly wrapped in half-lap wrappings which shall extend $\frac{1}{2}$ inch over the original insulation. The splice shall then be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying covering tape.

The jacket and splice shall then be covered by an additional layer of rubber insulating tape and two layers of friction tape—each layer consisting of half-lap wrappings and extending completely over the preceding layer. The tape shall extend at least 1 inch over the jacket. The completed splice shall be given one coat of bituminous weatherproof paint.

(c) When the transformer housing or junction box is furnished with cable bushings, the underground supply cable shall be brought through the bushings and internal connections shall be made as recommended by the manufacturer. The contractor shall ascertain that the rubber bushing inserts are of correct size for the underground cable. The use of incorrect sizes shall not be permitted. After the cable is connected, the bushings shall be drawn up tightly on the rubber jacket of the cable. The access cover and gasket shall be brushed clean and assembled in accordance with the manufacturer's installation instructions.

(d) When a bare neutral is used, this shall be installed and connected as described in the manufacturer's installation instructions.

115-3.5 ASSEMBLING THE UNIT. The elevated marker light shall be assembled in accordance with the manufacturer's instructions. The transformer secondary shall be connected to the lamp leads by means of the disconnecting plug and receptacle provided with the unit, and *this joint shall not be taped*. The disconnecting plug and receptacle shall be located above ground and under the cone. If necessary, a splice may be made between the receptacle and transformer. This splice shall be made in accordance with Paragraph 3.4 (b). A lamp of the proper rating shall be installed in the fixture.

115-3.6 BEAM ADJUSTMENT. After installation, the contractor shall orient the asymmetric lens of each optical system so that the two concentrated beams of light shine up and down the runway strip or taxiway, and are "toed-in" symmetrically toward the centerline. The final adjustment of the asymmetric lenses shall be made at night, and shall be to the satisfaction of the engineer.

115-3.7 TESTS. The completed system shall be tested in accordance with the "Testing" provisions of Item L-118, "Installation of Airport Underground Cable for Small Airports"; or L-108, "Installation of Underground Cable for Large Airports," or as directed by the engineer. The engineer shall also test the anchoring of the cones by the stakes.

METHOD OF MEASUREMENT

115-4.1 The quantity of lights to be paid for under this item shall be the number of each type of elevated lights installed as completed units in place, ready for operation, and accepted by the engineer.

BASIS OF PAYMENT

115-5.1 Payment for lights shall be made at the contract unit price for each complete elevated light installed in place and accepted by the engineer, which price and payment shall constitute full compensation for furnishing and installing the elevated light, including stakes and transformer or junction box; for furnishing and installing any necessary conduit or fittings for the cable entrance; for furnishing and installing the lamp; for making all cable connections; for adjusting the light beam; for testing and furnishing all testing equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-115-5.1 Installation of Airport Elevated Marker Lights for 600-Volt Series or Multiple Circuits, Stake Mounted Type—per each.

ITEM L-116 INSTALLATION OF AIRPORT ELEVATED MARKER LIGHTS, COLUMN-MOUNTED TYPE

DESCRIPTION

116-1.1 This item shall consist of elevated marker lights, for 600-volt series or multiple circuits, column-mounted type without concrete pads, furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installing of transformers or junction boxes and, if specified, a concrete anchor. This item shall also include all cable connections, the furnishing and installing of all lamps, the testing of the installation, and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

116-2.1 ELEVATED RUNWAY AND STRIP LIGHTS. The elevated marker lights shall be of a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-802, "Specification for Elevated Runway and Strip Marker Lights," and shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fitting, cone, column mounting assembly and, if required, a transformer or junction box.

116-2.2 TAPE. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Friction tape shall conform to Federal Specification HH-T-101.

116-2.3 CONCRETE. The concrete for anchors shall be proportioned, placed and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

CONSTRUCTION METHODS

116-3.1 PLACING THE LIGHTS. The elevated lights shall be installed at the approximate locations shown on the plans. The exact location shall be as directed by the engineer in charge.

116-3.2 TRANSFORMER AND JUNCTION BOX INSTALLATION. If a transformer or junction box is required for the operation of the elevated light, it shall be installed by one of the following methods:

(a) *Series Transformers.* The series transformer shall be buried directly in the earth. The top shall be not less than 14 inches below ground level and the leads shall be located at the bottom. The central stake shall be at least 12 inches away from the transformer, unless the transformer housing is part of the stake. Connections shall be made as described in Paragraph 3.6 (a), (b), or (c), as required. After connections are made, the bedding material shall be laid, the transformer placed in the hole, and backfill begun. All bedding and backfill material shall be either earth or sand containing no particles that would be retained on a 1-inch sieve. The layer of bedding under the transformer shall be 3 inches thick, loose measurement. When separate transformers are used the secondary lead shall be laid underground from the transformer to the column, at which point it shall be brought out of the ground. All backfill material shall be thoroughly tamped and compacted. If necessary to obtain compaction, the backfill material shall be moistened or aerated as required.

(b) *Multiple Transformers or Junction Boxes.* Multiple transformers or junction boxes shall be placed in the earth with the cover accessible at ground level for replacement of fuses. Connections shall be made as described in Paragraph 3.6 (a), (b), or (c), as required. The transformer shall be assembled to or near the central column in accordance with the manufacturer's recommendations. Backfill and compaction shall be in accordance with Paragraph 3.3.

116-3.3 CENTRAL COLUMN INSTALLATION. If the central column is designed to be driven, this shall be done in accordance with the manufacturer's recommendations. If not designed for driving, the excavation for the central column shall be not less than 6 inches in diameter. The central column shall be installed to a sufficient depth so that the shearing groove of the breakable coupling shall not extend more than $3\frac{1}{2}$ inches above finished grade. Backfill shall be made with earth containing no particles that would be retained on a 1-inch sieve. All backfill material shall be thoroughly tamped and compacted. If necessary to obtain compaction, the backfill material shall be moistened or aerated as required. Central column shall be vertical to within 3 degrees.

116-3.4 CONCRETE ANCHOR. If specified on the proposal, the central stake shall be backfilled with concrete to form an anchor. The design of the concrete anchor shall be in accordance with dimensions shown on the plans. If used, construction forms shall be removed after the concrete has set. The anchor shall rest on undisturbed soil or on earth backfill which has been screened and compacted as described in Paragraph 3.3.

116-3.5 ASSEMBLING THE UNIT. The elevated marker light shall be assembled in accordance with the manufacturer's installation instructions. The junction box or transformer secondary shall be connected to the lamp leads by means of the disconnecting plug and receptacle provided with the unit, and *this joint shall not be taped*. If necessary, a splice may be made between the receptacle and transformer. This splice shall be made in accordance with

Paragraph 3.6 (b). A lamp of the proper rating shall be installed in the fixture. The distance from finished grade to the top of the fixture shall be as indicated on the plans, but in any event, shall not exceed 30 inches.

116-3.6 CABLE CONNECTIONS. Underground cable will be installed between the units as a separate item, and the contractor shall connect this cable to the transformer or junction box. The connection to the underground cable supply shall be made by one of the following methods:

(a) *Plug and Receptacle Connection.* The plug and receptacle shall first be cleaned. A single band of rubber tape shall be placed around the joined plug and receptacle. The ends of the tape shall butt cleanly. The surface of the plug and receptacle and tape band shall be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying covering tape. The joint shall then be wrapped with a layer of rubber tape which shall be applied tightly and shall be half lapped extending at least $1\frac{1}{2}$ inches each side of the joint. One layer of friction tape shall then be added. This layer shall be half lapped and shall completely cover the rubber tape. Wraps shall be essentially smooth and compact.

(b) *Spliced Connection.* Leads shall be prepared for splicing by removing adequate insulation and jacket to permit the type of splice being made. If the cable has a filler between insulation and jacket, the jacket shall be cut back to expose at least 1 inch of insulation, and care shall be taken not to cut into cable insulation. The ends of the insulation on each conductor shall be penciled down. Fillers, if used, shall be cut off flush with the jacket. Bare wire shall be made bright and clean for all types of splices.

Western Union splices or solderless connectors of the proper size for the conductor shall be used. The contractor shall install the solderless connector or make a Western Union joint which is mechanically and electrically secure. The Western Union joint shall be soldered and care shall be taken not to burn the insulation. A noncorrosive paste flux shall be used for all soldered joints.

Each conductor shall be covered with rubber tape to approximately one and one-half times the thickness of the original insulation. The rubber tape shall be tightly wrapped in half-lap wrappings which shall extend $\frac{1}{2}$ inch over the original insulation. The splice shall then be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying the covering tape.

The jacket and splice shall then be covered by an additional layer of rubber insulating tape and two layers of friction tape—each layer consisting of half-lap wrappings and extending completely over the preceding layer. The tape shall extend at least 1 inch over the jacket. The completed splice shall be given one coat of bituminous weather-proof paint.

(c) When the transformer housing or junction box is furnished with cable bushings, the underground supply cable shall be brought through the bushings, and internal connections shall be made as recom-

mended by the manufacturer. The contractor shall ascertain that the rubber bushing inserts are of correct size for the underground cable. The use of incorrect sizes shall not be permitted. After the cable is connected, the bushings shall be drawn up tightly on the rubber jacket of the cable. The access cover and gasket shall be brushed clean and assembled in accordance with the manufacturer's installation instructions.

(d) When a bare neutral is used, this shall be installed and connected as described in the manufacturer's installation instructions.

116-3.7 LEVELING AND BEAM ADJUSTMENT. The optical system shall be leveled to within 1 degree. Leveling shall be accomplished as recommended by the manufacturer.

After leveling, the contractor shall adjust the asymmetric lens of each optical system so that the two concentrated beams of light shine up and down the runway, strip, or taxiway and are "toed in" symmetrically toward the centerline. The contractor shall be held responsible for the correct leveling, adjustment, and orientation of all elevated lights installed by him. Final adjustment of the asymmetric lenses shall be made at night and shall be to the satisfaction of the engineer.

116-3.8 TESTS. The completed system shall be tested in accordance with the "Testing" provisions of Item L-118, "Installation of Underground Cable for Small Airports," or Item L-108, "Installation of Underground Cable for Large Airports," or as directed by the engineer. The engineer shall also test the anchoring of the units.

METHOD OF MEASUREMENT

116-4.1 The quantity of lights to be paid for under this item shall be the number of each type of elevated marker lights installed as completed units in place, ready for operation, and accepted by the engineer.

BASIS OF PAYMENT

116-5.1 Payment for lights shall be made at the contract unit price for each complete elevated marker light installed in place and accepted by the engineer, which price and payment shall constitute full compensation for furnishing and installing the elevated marker light including a central column mounting and transformer or junction box; for furnishing and installing the concrete anchor, if required; for furnishing and installing any necessary conduit or fittings for the cable entrance; for furnishing and installing the lamp; for making all cable connections; for adjusting the light beam; for testing and furnishing all testing equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-116-5.1 Installation of Airport Elevated Marker Lights for 600-Volt Series or Multiple Circuits, Column Mounted Type Without Concrete Pad—per each.

ITEM L-117 INSTALLATION OF AIRPORT ILLUMINATED WIND CONE FOR SMALL AIRPORTS

DESCRIPTION

117-1.1 This item shall consist of an illuminated wind cone for small airports furnished and installed in accordance with this specification, at the location and in conformity with the dimensions, design, and details shown on the plans.

Included in this item shall be the furnishing and installation of a concrete foundation pad, or a wooden platform, whichever type of mounting is specified; and, if required, a booster transformer. This item shall also include all cable connections, conduit, conduit fittings, lamps, a padlock, and the testing of the installation and all incidentals necessary to place it in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

117-2.1 WIND CONE. The illuminated wind cone shall be a type approved by the Office of Airports, Civil Aeronautics Administration, Washington 25, D. C., as conforming to the requirements of Specification L-807, "Specification for Illuminated Wind Cone for Small Airports," and shall be supplied in the quantity specified in the proposal. The illuminated wind cone shall be completed with hinged steel pole, a shaft assembly with bearing supports, a fabric cone, a lighting fixture assembly, and an obstruction light.

117-2.2 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH, and shall be of the size, number of conductors, and service voltage specified on the plans and/or proposal.

117-2.3 TAPE. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Friction tape shall conform to Federal Specification HH-T-101.

117-2.4 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

117-2.5 CONCRETE. The concrete for pads shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

117-2.6 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed bars, and shall meet the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

117-2.7 PAINT. (a) Priming paint for bare metal surfaces shall be red lead in oil or zinc chromate conforming respectively to Federal Specifications TT-R-191 and TT-Z-415.

(b) Priming paint for galvanized metal surfaces shall be zinc dust-zinc oxide conforming to Federal Specification TT-P-641.

(c) International-Orange paint for body and finish coats on metal and wood surfaces shall consist of a ready-mixed, bright, nonfading International-Orange (orange-yellow No. 106) gloss paint meeting the requirements of the Federal Specification TT-P-59, Type B.

(d) White paint for body and finish coats on metal or wood surfaces shall be ready-mixed paint conforming to Federal Specification TT-P-40, Type II; except Type I, Class B, shall be used where white paint is subject to discoloration by sulphide fumes.

(e) Priming paint for wood surfaces shall be mixed on the job by thinning the above-specified chrome yellow or white paint by adding one-half ($\frac{1}{2}$) pint of raw linseed oil to each gallon.

117-2.8 PADLOCK. Padlock shall be designed for outdoor use and for use with the padlocking means provided to secure the hinged steel pole in position to the satisfaction of the engineer.

CONSTRUCTION METHODS

117-3.1 GENERAL. The contractor shall furnish and install the illuminated wind cone on the ground or on a building roof as shown on the plans. The exact location shall be as directed by the engineer.

117-3.2 INSTALLATION ON FIELD. Where the wind cone is to be installed on the field, it shall be mounted on a concrete foundation and installed as shown on the plans. The illuminated wind cone shall be assembled and erected in a vertical position in accordance with the manufacturer's installation instructions.

117-3.3 INSTALLATION ON ROOF. Where the wind cone is to be installed on a roof, it shall be mounted on a wooden platform constructed and installed in accordance with details shown on the plans. The support shall be carried through the roofing surface and shall be securely attached and braced to the roof trusses, and the roof resealed. The illuminated wind cone shall be assembled and erected in a vertical position in accordance with the manufacturer's installation instructions.

117-3.4 ELECTRICAL CONNECTIONS. The contractor shall furnish all labor and materials, and shall make complete electrical connections in accordance with the wiring diagram furnished with the project plans. All wiring to wind cones mounted on buildings shall be run in not less than one (1) inch galvanized rigid steel conduit.

If underground cable for power feed from the transformer vault to the illuminated wind cone site is required, the cable shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-108, "Installation of Underground Cable," or in

accordance with (and paid for by linear foot measurement as described in) Item L-118, "Installation of Underground Cable for Small Airports," as stipulated in the proposal. If duct is required for this cable installation under paved areas, it shall be installed in accordance with (and paid for by linear foot measurements as described in) Item L-110, "Installation of Underground Duct."

117-3.5 BOOSTER TRANSFORMER. When specified, the contractor shall furnish and install a booster auto-transformer to compensate for voltage drop to the lamps. The booster transformer shall be installed in a suitable weatherproof housing, as indicated on the plans. If this booster transformer is required for installation in the transformer vault, it shall be installed in accordance with (and paid for as described in) Item L-109, "Installation of Airport Transformer Vault and Equipment."

117-3.6 PAINTING. Three coats of International-Orange paint shall be applied (one prime, one body, and one finish) to all exposed material installed under this item except the fabric cone, obstruction light globe, lamp reflectors, and except the wind cone assembly which, if painted on receipt, shall be given one finish coat of International-Orange.

117-3.7 LAMPS. The contractor shall furnish and install lamps in the lighting fixture assembly, and in the obstruction light, in accordance with the manufacturer's installation instructions.

117-3.8 PADLOCK. The contractor shall furnish and install a padlock for securing the hinged lower section in position. Upon completion of the installation two sets of keys for the padlock shall be delivered to the engineer.

METHOD OF MEASUREMENT

117-4.1 The quantity of wind cones to be paid for under this item shall be the number of illuminated wind cones installed as completed units in place, ready for operation, and accepted.

BASIS OF PAYMENT

117-5.1 Payment for wind cones shall be made at the contract unit price for each complete job furnished and installed in place by the contractor and accepted by the engineer, which price and payment shall constitute full compensation for furnishing, installing, and erecting the wind cone, the concrete foundation or wood platform, whichever is specified; for painting all exposed material; for painting the roof, if specified; for furnishing and installing a booster transformer, if specified; for all wiring, lamps, conduit, and for making all necessary connections; for adjusting and testing, and for furnishing all test equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-117-5.1 Illuminated Wind Cone—per unit.

ITEM L-118 INSTALLATION OF AIRPORT UNDERGROUND CABLE FOR SMALL AIRPORTS

DESCRIPTION

118-1.1 This item shall consist of underground cable furnished and installed in accordance with this specification at the locations and in conformity with the dimensions, designs, and details shown on the plans. This item shall include the installation of cable installed in trench, in duct, or conduit. It shall also include all splicing, cable marking, and testing of the installation and all incidentals necessary to place the cable in operating condition as a completed unit to the satisfaction of the engineer. This item shall not include the installation of the duct or conduit.

MATERIALS

118-2.1 CABLE. Underground cable shall conform to the requirements of Specification L-824, "Underground Electrical Cables for Airport Lighting Circuits." Cable type, size, number of conductors, and service voltage shall be as specified on the plans and/or proposal.

118-2.2 TAPE. (a) Rubber insulating tape shall conform to Federal Specification HH-T-111.

(b) Friction tape shall conform to Federal Specification HH-T-101.

118-2.3 CONCRETE. Concrete for cable markers shall conform to Item P-610, "Structural Portland Cement Concrete."

CONSTRUCTION METHODS

118-3.1 GENERAL. The contractor shall install the specified cable at the approximate locations indicated on the airport lighting lay-out plans. The engineer shall indicate specific locations. No cable splices shall be made between runway marker lights spaced less than 220 feet apart, except for the connections of the underground cable to the lighting units or insulating transformers. The installation of lighting units and transformers and their connection to the underground cable will be accomplished as a separate item.

118-3.2 INSTALLATION BY CABLE PLOW. If stipulated on the proposal, the cable may be installed by the use of a cable plow. The cable shall either be unreeled on the plow or in not over 50-feet

lengths ahead of the plow. The cable shall be fed into the plow in such a manner as to relieve all tension on it above ground. This shall be done to the satisfaction of the engineer who shall determine that the cable is installed without damaging the sheath, injuring the insulation, or stretching the conductor. Cable depth, separations, clearances, and slack shall be as specified in Paragraphs 3.3 and 3.4. The opening in the soil shall be closed by any necessary backfill and by rolling or tamping.

118-3.3 TRENCHING. Trenches for cables may be excavated manually by plows or with mechanical trenching equipment. Trenches shall be excavated so that a minimum surface area is disturbed. Road patrols or graders shall not be used to excavate the trench with their blades. The bottom surface of trenches shall be essentially smooth and free from coarse aggregate.

Unless otherwise specified, cable trenches shall be excavated to a minimum depth of 12 inches below finished grade except as follows:

- a. When off the airport or crossing under a roadway or driveway the minimum depth shall be 36 inches, unless otherwise specified.
- b. Minimum cable depth when crossing under a railroad track shall be 42 inches, unless otherwise specified.

When rock excavation is encountered, the rock shall be removed to a depth of at least 3 inches below the required cable depth. The contractor shall ascertain before bidding the type of soil, aggregate, or rock to be excavated.

118-3.4 INSTALLATION IN TRENCHES. The contractor shall install the cable without bends or kinks having a radius less than 10 times the diameter of the cable.

Cables shall be unreeled and carefully placed along the bottom of the trench. The cable shall not be pulled into the trench from one end.

Cables crossing over each other shall have a minimum of 3-inch vertical displacement with the topmost cable kept at or below the minimum required depth below finished grade.

Where specified on the plans, the cable in the trench shall be protected by the installation of a 1-inch thick creosoted wood plank, or planks. Types of wood not requiring creosoting may omit this if specified in the proposal. Before laying the planks in the trench, a 3-inch layer (loose measurement) of sand or clean earth, free from any mineral aggregate particles that would be retained on a $\frac{1}{4}$ -inch sieve, shall be placed over the cable and tamped to the approximate density of the adjacent undisturbed soil. The planks shall then be laid end to end in the trench to cover the cable, or cables, after which the trench shall be backfilled and compacted, as specified elsewhere in this section.

To allow for ground settlement, approximately 1 foot of cable slack shall be left on each side of all splices, insulating transformers, light units, and at all other points where cable connections are made.

118-3.5 BACKFILLING. After the cable has been installed the trench shall be backfilled by one of the following methods:

(a) *For Trenches 12 Inches Deep.* The first layer above the cable shall be 3 to 6 inches (loose measurement) of earth or sand which shall consist of not less than 75 percent fine material, such as will pass a $\frac{1}{4}$ -inch sieve. The remaining 25 percent of the first layer shall not contain stone or aggregate larger than 1-inch maximum diameter. The balance of the backfill may consist of material excavated from the trench. The completed backfill shall then be thoroughly tamped and compacted to the approximate density of the surrounding soil.

(b) *For Trenches Deeper Than 12 Inches.* The first layer of backfill shall be as described in Paragraph (a) above. All succeeding layers of backfill shall not exceed 12 inches in depth (loose measurement), and may consist of material excavated from the trench. Each of these succeeding layers shall be thoroughly tamped and compacted to the approximate density of the surrounding soil.

Trenches in solid rock shall be backfilled with a 3-inch layer (compacted measurement) of bedding material before installation of the cable. The bedding layer shall be tamped and compacted to the density specified above, and shall be earth or sand containing no mineral aggregate particles that would be retained on a $\frac{1}{4}$ -inch sieve.

118-3.6 INSTALLATION IN DUCT OR CONDUIT. Where cable is to be installed under runways, taxiways, and other paved areas utilizing existing ducts or conduit, it shall be installed in the duct or conduit in accordance with the instructions in this paragraph. New duct or conduit shall be installed as a separate item in accordance with Item L-110. The maximum number and voltage ratings of cables installed in each single duct or conduit, and the current carrying capacity of each cable shall be in accordance with the latest National Electrical Code, or local code agency having jurisdiction. The cable shall be installed in such manner and by such methods to insure against harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. No splices or joints will be permitted to be drawn inside ducts. Where more than one cable is to be installed in a duct under the same contract, all shall be pulled in the duct at the same time. Duct or conduit markers temporarily removed for excavations shall be replaced as required.

118-3.7 RESTORATION. Except for paved areas of the airport, the contractor shall restore all disturbed areas to their original condition. After all work is completed, the contractor shall remove all tools and other equipment used by him, leaving the site free, clear, and in good condition.

118-3.8 SPLICING. If required, splices in the underground cable shall be made by one of the following methods:

(a) *Plug and Receptacle Connection.* The plug and receptacle shall first be cleaned. A single band of rubber tape shall be placed around the joined plug and receptacle. The ends of the tape shall butt cleanly. The surface of the plug and receptacle and the tape band shall be covered with a layer of rubber cement. This cement shall be

allowed to become tacky before applying covering tape. The joint shall then be wrapped with a layer of rubber tape which shall be applied tightly and shall be half lapped, extending at least $1\frac{1}{2}$ inches each side of the joint. One layer of friction tape shall then be added. This layer shall be half lapped and shall completely cover the rubber tape. The layers of tape shall be wrapped essentially smooth and compact.

(b) *Splice Connection.* Cables shall be prepared for splicing by removing adequate insulation and jacket to permit the type of splice being made. If the cable has a filler between the insulation and jacket, the jacket and filler shall be cut back to expose at least 1 inch of the insulation, and care shall be taken not to cut into cable insulation. The ends of the insulation on each conductor shall be penciled down. Bare wire shall be made bright and clean for all types of splices.

Western Union splices or solderless connectors of the proper size for the conductor shall be used. The contractor shall install the solderless connector or make a Western Union joint which is mechanically and electrically secure. The Western Union joint shall be soldered and care shall be taken not to burn the insulation. A non-corrosive paste flux shall be used for all soldered joints.

Each conductor shall be covered with rubber tape to approximately one and one-half times the thickness of the original insulation. The rubber tape shall be tightly wrapped in half-lap wrapping which shall extend $\frac{1}{2}$ inch over the original insulation. The splice shall then be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying covering tape wrappings.

The cable jacket and splice shall then be covered by an additional layer of rubber insulating tape and two layers of friction tape, each layer consisting of half-lap wrappings and extending completely over the preceding layer. The tape shall extend at least 1 inch over the jacket. The completed splice shall be given one coat of bituminous weatherproof paint.

118-3.9 CABLE MARKERS. If specified in the proposal, cable markers shall be installed as follows: The location of runway, strip, and boundary light circuit lead-ins shall be marked by a concrete slab marker 2 feet square and 4 inches thick. Each cable run from the line of lights to the equipment vault or building shall be marked at the point where the cable leaves the trench along the runway, and shall also be marked at approximately every 200 feet along the cable run, with an additional marker at each change of direction of cable run.

All other cable buried directly in the earth shall be marked in the same manner. The contractor shall not install slab markers where cable lies in straight lines between obstruction light poles which are spaced 300 feet apart, or less. Cable markers shall be installed flat in the ground immediately above the cable, with approximately 1 inch projecting above the surface. The contractor shall impress the word

"Cable" on each cable-marking slab. He shall also impress additional circuit identification symbols on each slab if so directed by the engineer. The letters shall be approximately 4 inches high and 3 inches wide, with stroke $\frac{1}{2}$ inch wide and $\frac{1}{4}$ inch deep.

The location of each underground cable splice also shall be marked by a concrete marker slab placed above the splice, with approximately 1 inch of the slab projecting above the surface. The concrete marker shall be as described above. The contractor shall impress the word "Splice" on each splice-marking slab. He shall also impress additional circuit identification symbols on each slab if so directed by the engineer. The letters shall be approximately 4 inches high and 3 inches wide, with stroke $\frac{1}{2}$ inch wide and $\frac{1}{4}$ inch deep.

118-3.10 TESTING. The contractor shall furnish all necessary equipment and appliances for testing the underground cable circuits after installation. The contractor shall test and demonstrate, to the satisfaction of the engineer, the following:

- a. That all lighting, power, and control circuits are continuous and free from short circuits.
- b. That all circuits are free from unspecified grounds.
- c. That the resistance to ground of all nongrounded series circuits is not less than 50,000 ohms.
- d. That the resistance to ground of all nongrounded conductors of multiple circuits is not less than 100,000 ohms.
- e. That all circuits are properly connected in accordance with the applicable wiring diagrams.
- f. That all circuits are operable, which demonstration shall include functioning of each control not less than ten times and continuous operation of each lighting and power circuit for not less than one-half hour.

METHOD OF MEASUREMENT

118-4.1 The quantity of trench to be paid for shall be the linear feet of trench, including the excavation, backfill, and restoration, completed, measured as excavated, and accepted as satisfactory.

Separate measurement shall be made for trenches excavated for the installation of one cable and for the installation of two or more cables.

118-4.2 The footage of cable installed in trench to be paid for shall be the number of linear feet of cable installed in trench, measured in place, completed, ready for operation, and accepted as satisfactory.

Separate measurement shall be made for each cable installed in trench, and for the different kinds of cable.

118-4.3 The footage of cable installed in duct or conduit to be paid for shall be the number of linear feet of cable installed in duct or conduit, measured in place, completed, ready for operation, and accepted as satisfactory.

Separate measurement shall be made for each cable installed in duct or conduit, and for the different kinds of cable.

118-4.4 The footage of cable to be paid for shall be the linear feet of cable in place, installed by cable plow, including plowing operations and any required backfill, compaction and restoration, measured in place, completed, ready for operation, and accepted as satisfactory. Separate measurement shall be made for the different kinds of cable.

BASIS OF PAYMENT

118-5.1 The footages of trench or cable measured as provided above shall be paid for at the contract unit price for each linear foot of trench and per linear foot of cable installed in the trench or duct in place by the contractor and accepted by the engineer. The trenching shall be paid for on an unclassified basis and no allowance shall be made for rock or other special conditions encountered. The price and payment shall constitute full compensation for furnishing and placing cable and all other necessary materials; for locating and cleaning duct lines; for pulling cables in ducts; for installation with cable plow, if specified; for all trenching, including excavation, backfill, and reconditioning; for installing planks and cable markers; for splicing, where required and permitted; for disposal of surplus materials; for testing of all completed circuits or portions thereof; and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

Item L-118-5.1 Cable Trench—per linear foot.

Item L-118-5.1 Underground Cable, in Place in Trench—per linear foot.

Item L-118-5.1 Underground Cable, in Place in Duct or Conduit—per linear foot.

Item L-118-5.1 Underground Cable, in Place Installed by Plow—per linear foot.

ITEM L-119 INSTALLATION OF AIRPORT OBSTRUCTION LIGHTS

TYPE L-810

DESCRIPTION

119-1.1 This item shall consist of Type L-810 Obstruction Lights, including series- and multiple-circuit types, furnished and installed in accordance with this specification, at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installing of wood poles, steel or iron pipes, or other supports, if stipulated on the plans or in the job specifications.

This item shall also include all wire and cable connections, the furnishing and installing of all necessary conduit and fittings, insulators, pole steps, pole cross arms, the painting of poles and pipes, the furnishing and installing of all lamps and, if required, film-cutouts; the furnishing and installing of insulating transformers for series units; the servicing and testing of the installation and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

119-2.1 OBSTRUCTION LIGHTS. The obstruction lights shall be a type approved by the Civil Aeronautics Administration as conforming to the requirements of Specification L-810, "Obstruction Light." The obstruction lights shall be supplied in the quantity and type specified in the proposal.

119-2.2 TRANSFORMER HOUSING. The transformer housing shall consist of a Type AN-2512-11 shallow base assembly complete with bolts, gasket, and metal cover. Where specified, the housing shall consist of Type AN-2512-1 deep base assembly complete with bolts, gasket, and metal cover.

119-2.3 CONDUIT. (a) Fiber conduit and fittings shall be in accordance with Federal Specification W-C-581.

(b) Steel conduit and fittings shall be in accordance with Federal Specification WW-C-581.

119-2.4 WIRE. Wire in conduit above ground shall conform to the requirements of Federal Specification J-C-103, Type R or RH; and shall be of the size, number of conductors, and service voltage shown on the plans and/or proposal.

119-2.5 MISCELLANEOUS. Paint, poles, pole steps, insulators, and all other miscellaneous materials necessary for the completion of this item shall be new and first-grade commercial products; and shall be entirely suitable for the application.

CONSTRUCTION METHODS

119-3.1 PLACING THE OBSTRUCTION LIGHTS. The contractor shall furnish and install single or double obstruction lights as specified in the proposal and shown on the plans. The obstruction lights shall be mounted on poles, buildings, or towers approximately at the locations shown on the plans. The exact location shall be as directed by the engineer.

119-3.2 INSTALLATION ON POLES. If obstruction lights are to be mounted on poles, each obstruction light shall be installed with its hub at least as high as the top of the pole. All wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. If specified, pole steps shall be furnished and installed, the lowest step being five (5) feet above ground level. Steps shall be installed alternately on diametrically opposite sides of the pole to give a rise of 18 inches for each step. Conduit shall be fastened to the pole with galvanized steel pipe straps and shall be secured by galvanized lag screws. Poles shall be painted as shown on the plans and in the specifications.

When obstruction lights are to be installed on existing telephone or power poles a fiber insulating sleeve of adequate diameter and not less than four (4) feet long, shall be installed to extend six (6) inches above the conductors on the upper cross arm and at least eighteen (18) inches below the conductor on the lower cross arm. The details of this installation shall be in accordance with the plans.

119-3.3 INSTALLATION ON BEACON TOWER. If specified on the plans, two obstruction lights shall be mounted on top of the beacon tower. The conduit shall screw directly into the obstruction light fixtures, and shall support them at a height equal to the highest point of the rotating beacon. All wiring shall be run in not less than one (1) inch galvanized rigid steel conduit. If obstruction lights are specified at lower levels, the contractor shall install not less than one (1) inch galvanized rigid steel conduit with standard conduit fittings for mounting the fixtures. The fixtures shall be mounted in an upright position in all cases. The conduit shall be fastened to the tower members with "Wraplock" straps, clamps, or approved fasteners, spaced approximately five (5) feet apart. No conduit shall be laid on the beacon platform floor. Three coats of International-Orange paint shall be applied (one prime, one body, and one finish coat) to all exposed material installed under this item except obstruction light globes.

119-3.4 INSTALLATION ON BUILDINGS, TOWERS, SMOKESTACKS, ETC. If obstruction lights are to be installed on buildings or similar structures, the installation shall be made in accordance with details shown on the plans. The hub of the obstruction light shall not be less than one (1) foot above the highest point of the obstruction except in the case of smokestacks where the uppermost units shall be mounted about six (6) feet below the top of the stack. Conduit supporting the obstruction light units shall be fastened to wooden structures with galvanized steel pipe straps, and

shall be secured to wood buildings by 1½-inch, No. 10, galvanized wood screws. Conduit shall be fastened to masonry structures by the use of expansion shields, screw anchors, and toggle bolts using No. 10 or larger galvanized wood or machine screws. Conduit fastened to structural steel shall have the straps held with not smaller than No. 10, round-head, machine screws in drilled and tapped holes. Fastenings shall be approximately five (5) feet apart. Three coats of International-Orange paint shall be applied (one prime, one body, and one finish coat) to all exposed material installed under this item except obstruction-light globes.

119-3.5 SERIES INSULATING TRANSFORMERS. The series obstruction light, Type L-810, does not include a film cutout; therefore, an insulating transformer must be used with each series lamp. Double series units of this type require two insulating transformers. The series transformer shall conform to one of the following specifications:

- a. Direct burial type for use with 600-volt series circuits.* The transformer shall be a type approved by the Civil Aeronautics Administration, Office of Airports, as conforming to Specification L-803, "Individual Lamp Series-to-Series Insulating Transformer for 600-volt Series Circuits," and shall be Type II for a 100-watt load.
- b. Base-mounted type for use with 3,000-volt series circuits.* The transformer shall be a type approved by the Civil Aeronautics Administration, Office of Airports, as conforming to Specification L-804, "Individual Lamp Series-to-Series Insulating Transformer for 3,000-volt Series Circuits," and shall be Type II for a 100-watt load.

119-3.6 TRANSFORMER HOUSING. If insulating transformers are specified for use on 3,000-volt series circuits, the transformer shall be housed in a metal base in accordance with the details shown on the plans.

119-3.7 WIRING. The contractor shall furnish all necessary labor and materials and shall make complete electrical connections from the underground cable or other source of power in accordance with the wiring diagram furnished with the project plans. If underground cable for the power feed and duct for this cable installation under paved areas is required, the cable and duct shall be installed in accordance with (and paid for by linear foot measurement as described in) Item L-118, "Installation of Airport Underground Cable for Small Airports," or Item L-108, "Installation of Underground Cable for Large Airports," and Item L-110, "Installation of Underground Duct."

119-3.8 LAMPS. The contractor shall furnish and install in each unit one or two lamps, as required conforming to the following requirements:

- a. Series Lamp*—6.6-ampere, 1020-lumen, A-21 clear bulb, medium prefocus base.

b. Multiple Lamps—100- or 111-watt; or 60- or 67-watt, 115- or 120-volt, A-21 clear bulb, medium screw base.

METHOD OF MEASUREMENT

119-4.1 The quantity of lights to be paid for under this item shall be the number of each type of obstruction light installed as completed units, in place, ready for operation, and accepted as satisfactory.

BASIS OF PAYMENT

119-5.1 Payment for lights shall be made at the contract unit price for each complete single or double, series or multiple, obstruction light, installed in place and accepted by the engineer, which price and payment shall constitute full compensation for furnishing and installing the obstruction light; for furnishing and installing a wood pole or steel supporting pole or mast, if specified; for furnishing and installing conduit and fittings; for painting the wood pole or steel mast, if specified; for furnishing and installing an insulating transformer for series units and, if specified, a base for housing the transformer; for making all necessary cable connections; for painting all exposed material; for furnishing and installing lamp(s); for adjusting and testing, and for furnishing all testing equipment; and for all labor, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-119-5.1 Airport Obstruction Light, In Place—per each.

ITEM L-121 INSTALLATION OF AIRPORT HIGH-INTENSITY RUNWAY MARKER LIGHTS

DESCRIPTION

121-1.1 This item shall consist of airport high intensity runway marker lights, furnished and installed in accordance with this specification, at the locations and in conformity with the dimensions, design, and details shown on the plans. Included in this item shall be the furnishing and installation of concrete pads or handholes for mounting the light units and the furnishing and installation of conduit lead-ins and field manholes, if required. This item shall also include all internal wire and cable connections, the testing of the installation, the adjustment of the light beams, and all incidentals necessary to place these lights in operation as a completed unit to the satisfaction of the engineer.

MATERIALS

121-2.1 HIGH INTENSITY RUNWAY LIGHT. The high intensity runway light shall be a type approved by the Office of Airports, Civil Aeronautics Administration, as conforming to the requirements of one of the following specifications: L-818, "Controllable Beam Bi-Directional High Intensity Runway Light"; L-819, "Fixed Focus Bi-Directional High Intensity Runway Light"; or L-820, "Fixed Focus, Uni-Directional High Intensity Runway Light." The high intensity lights shall be supplied in the quantity specified in the proposal. Each unit shall be furnished complete with a lens assembly of the color specified in the proposal, fixture, mounting assembly and, if required, a transformer. The mounting assembly shall consist of a fixture supporting column with breakable insert, base adapter plate, and one of the following base assemblies, as specified on the proposal:

- a. Shallow base assembly, Type AN-2513, complete with bolts, gasket, and cover.
- b. Deep base assembly, Type AN-2509, complete with bolts, gasket and cover.
- c. Base assembly as shown on the plans complete with bolts, gasket, and cover. The base flange shall provide mounting dimensions interchangeable with base Types AN-2509 and AN-2513.

121-2.2 CONCRETE. The concrete shall be proportioned, placed, and cured in accordance with Item P-610, "Structural Portland Cement Concrete."

121-2.3 REINFORCING STEEL. Reinforcing steel bars shall be intermediate or structural grade deformed bars, and shall meet

the requirements of A. A. S. H. O. (American Association of State Highway Officials) Specification M-31.

121-2.4 CONDUIT. Rigid steel conduit and fittings shall conform to the requirements of Federal Specification WW-C-581.

121-2.5 SQUEEZE CONNECTORS. Squeeze connectors shall be similar and equal to Crouse-Hinds Type CGB cable connector with neoprene rubber bushing of maximum durometer hardness of 40.

121-2.6 TEES. Large radius bend tees shall be similar and equal to Crouse-Hinds No. ET-43.

121-2.7 OTHER ELECTRICAL EQUIPMENT. Distribution transformers and oil fuse cut-outs for use in multiple distribution field manholes, and all other regularly used commercial items of electrical equipment not referenced by the above specifications, shall conform to the applicable rulings and standards of the American Institute of Electrical Engineers, the National Electric Manufacturers Association, or the American Standards Association Bulletins for equipment of this type. Manufacturers certification or test reports from a testing laboratory to the effect that the equipment meets these specifications shall be supplied when requested by the engineer. Such equipment shall, in all cases, be new and first-grade products. This equipment shall be supplied in the quantities required for the specific project, and shall incorporate the electrical and mechanical characteristics specified in the proposal and plans.

CONSTRUCTION METHODS

121-3.1 PLACING THE LIGHTS. The high intensity runway lights shall be installed at the approximate location indicated on the plans. The exact location shall be as directed by the engineer.

121-3.2 CONCRETE PAD. The lights shall be installed in concrete pads approximately 4 feet square, or 4 feet in diameter, made and formed in accordance with the details shown on the plans. The concrete pad shall not be prefabricated but shall be poured in place and shall rest on undisturbed soil. It shall be reinforced with steel bars formed and placed as indicated on the plans. The exposed concrete surface shall be finished smooth with a steel trowel or rubbed to a smooth finish. The pad shall be sloped as shown on the plans to provide proper drainage. After the concrete has set sufficiently the contractor shall remove the construction support and forms, clean out any debris which may be in the base, and install the plywood cover. The contractor shall install the permanent base adapter plate and the high-intensity light after wiring, and as described hereafter.

121-3.3 LEVELING. The base shall be adjusted and firmly held in place so that the machined upper surface of the base flange will extend $\frac{1}{4}$ inch above the surface of the concrete pad. The base flange shall be level within plus or minus 1 degree.

121-3.4 IDENTIFICATION NUMBER. The contractor shall impress an identifying number on the top surface of the pad on the

side nearest and parallel to the runway centerline. The number shall be approximately 4 inches high, 3 inches wide, with a $\frac{1}{2}$ -inch stroke. The numbers shall correspond with the numbers indicated on the lighting plan or as designated by the engineer.

121-3.5 INSTALLATION IN HANDHOLES. Where the plans require the light unit to be installed with a handhole, the provisions of the preceding paragraphs shall be observed, except that the concrete structure shall conform to the design and dimensions indicated on the plans.

121-3.6 CABLE ENTRANCE. Cable will be installed between the high intensity runway light units as a separate item and the contractor shall bring this cable into the bases as shown on the plans. If specified, the cable entrance to the base (or to conduit or tee leading into the base) shall be sealed by squeeze connectors. Galvanized cast iron conduit reducers shall be used where required. Where squeeze connectors are specified they shall be provided with a rubber bushing of correct size to fit the outside diameter of the cable. The connectors shall be tightened sufficiently to provide a watertight seal without deforming the insulation and sheath of the cable.

121-3.7 CABLE CONNECTIONS. In making cable connections to the high-intensity lights, the contractor shall pull cables into each light base and shall leave sufficient slack cable inside the base to permit all connections to be made above ground.

Cable connections shall be made to the transformer or fixture by one of the following methods:

(a) *Connection to Binding Post Terminals.* The insulation and jacket shall be removed from the conductor ends without nicking the conductor, and the ends of the insulation shall be sealed off. Exposed conductors shall then be securely connected to the terminals of the high intensity light. Ends of exposed conductor projecting through the terminals shall be clipped off.

(b) *Spliced Connection.* Leads shall be prepared for splicing by removing adequate insulation and jacket to permit the type of splice being made. If the cable has a filler between insulation and jacket, the jacket shall be cut back to expose at least 1 inch of insulation, and care shall be taken not to cut into cable insulation. The ends of the insulation on each conductor shall be penciled down. Fillers, if used, shall be cut off flush with the jacket. Bare wire shall be made bright and clean for all types of splices.

Western Union splices or solderless connectors of the proper size for the conductor shall be used. The contractor shall install the solderless connector or make a Western Union joint which is mechanically and electrically secure. The Western Union joint shall be soldered, and care shall be taken not to burn the insulation. A non-corrosive paste flux shall be used for all soldered joints.

Each conductor shall be covered with rubber tape to approximately one and one half times the thickness of the original insulation. The rubber tape shall be tightly wrapped in half lap wrappings which shall

extend $\frac{1}{2}$ inch over the original insulation. The splice shall then be covered with a layer of rubber cement. This cement shall be allowed to become tacky before applying the covering tape.

The jacket and splice shall then be covered by an additional layer of rubber insulating tape and two layers of friction tape—each layer consisting of half-lap wrappings and extending completely over the jacket. The completed splice shall be given one coat of bituminous weatherproof paint.

(c) *Connection to Disconnecting Terminals.* When the transformer housing is furnished with cable bushings, the underground supply cable shall be brought through the bushings and internal connections shall be made as recommended by the manufacturer. The contractor shall ascertain that the rubber bushing inserts are the correct size for the underground cable. The use of incorrect sizes shall not be permitted. After the cable is connected, the bushings shall be drawn up tightly on the rubber jacket of the cable.

(d) When a bare neutral is used, this shall be installed and connected as described in the manufacturer's installation instructions.

121-3.8 ASSEMBLING THE UNIT. The high-intensity runway light shall be assembled and connected in accordance with the manufacturer's installation instructions. Internal connections to lamp, or lamps, and, if used, beam-control motors and fan motors shall be made in accordance with the manufacturer's wiring diagrams. If a transformer is used, the secondary shall be connected to the lamp leads by one of the methods described in paragraph 3.7 (a), (b), or (c), or by the plug and receptacle provided with the unit. A lamp, or lamps, of the proper rating shall be installed in the fixture. The distance from finished grade to the top of the fixture shall be as indicated on the plans, but in any event shall not exceed 30 inches.

121-3.9 FIELD MANHOLE VAULTS. When specified, field manhole vaults shall be installed at the locations shown on the plans. These field manholes shall be constructed in accordance with details shown on the plans, and shall be furnished complete with the required electrical apparatus in the quantity and of the type, size, and electrical or mechanical characteristics specified in the proposal.

121-3.10 LEVELING AND BEAM ADJUSTMENT. The fixture shall be leveled to within 1 degree. Leveling shall be accomplished as recommended by the manufacturer's installation instructions.

After leveling, the contractor shall adjust each optical system in accordance with engineer's instructions. The contractor shall be responsible for the correct leveling, adjustment, and orientation of all high-intensity lights installed by him. Final adjustment shall be made at night and shall be to the satisfaction of the engineer.

121-3.11 TESTS. The completed system shall be tested in accordance with the "Testing" provisions Item L-108, "Installation of Underground Cable for Large Airports," or as directed by the engineer. The engineer shall also test the anchoring of the units and, if used, the movable beam mechanism.

METHOD OF MEASUREMENT

121-4.1 The quantity of lights to be paid for under this item shall be the number of each type of elevated marker lights installed as completed units in place, ready for operation, and accepted by the engineer.

BASIS OF PAYMENT

121-5.1 Payment for lights shall be made at the contract unit price for each complete high-intensity runway light installed in place and accepted by the engineer, which price and payment shall constitute full compensation for furnishing and installing the high-intensity runway light including a mounting assembly and, if required, a transformer; for furnishing and installing concrete pads; for furnishing and installing concrete pads with handholes, where specified; for furnishing, installing, and leveling the base assembly; for impressing identifying numbers in pad or manhole covers; for connecting the underground cable; for furnishing and installing metal conduit fittings and watertight bushings for cable entrances, if specified; for furnishing and installing field manhole vaults complete with transformer and all required electrical apparatus, if specified; for furnishing and installing all lamps; for making all necessary cable and wire connections; for leveling the fixture and adjusting the light beams; for testing and furnishing all testing equipment; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item L-121-5.1 Airport High-Intensity Runway Marker Lights, in Place—per unit.

DIVISION VI—APPENDIX A

TEST T-611 COMPACTION CONTROL TESTS

GENERAL

611-1.1 DESCRIPTION. This specification shall govern the determination of the maximum density, field density, and percent compaction of those materials for which a minimum percent compaction is specified. It covers the basic procedure to be followed in performing the test for maximum density, and describes several procedures that may be used to determine the field density and percent compaction.

The engineer shall select the method most suitable for determining the field density.

In all cases density shall be stated as the dry weight in pounds per cubic foot.

MAXIMUM DENSITY TEST FOR SOIL MATERIALS (Classes 3, 4, and 5 Airports)

611-2.1 DEFINITION. Maximum density is defined as the maximum dry weight in pounds per cubic foot obtained when a material is mixed with different percentages of water and compacted in a standard manner as described in this specification. The percentage of water at which maximum density is obtained represents the moisture content necessary to give the maximum compaction.

611-2.2 APPARATUS. The apparatus shall conform to the requirements of A. A. S. H. O. Method T-99 with the following changes:

- (a) The weight of the metal hammer shall be ten (10.0) pounds instead of five and five-tenths (5.5) pounds. There shall be no change in the diameter of the hammer.
- (b) The specified drop shall be eighteen (18) inches instead of twelve (12) inches.

611-2.3 MATERIAL. The material to be used in this test shall be that portion of the sample passing the No. 4 mesh sieve.

611-2.4 PROCEDURE. The procedure and computations to determine maximum density shall be in accordance with A. A. S. H. O. Method T-99 with the following exceptions:

- (a) The sample shall be compacted using twenty-five (25) blows per layer of a ten (10) pound hammer dropped from a height of eighteen (18) inches instead of a five and five-tenths (5.5) pound hammer dropped from a height of twelve (12) inches.

- (b) The sample shall be compacted using five equal layers of material instead of three.
- (c) If the sample shows undue breaking down or tendency to pulverize during the compaction process a new soil sample shall be used with each moisture change. If the sample does not show undue breaking down it is preferable to use the same sample for the entire test if possible.

MAXIMUM DENSITY TEST FOR SOIL MATERIALS

(Classes 1 and 2 Airports)

611-3.1 DEFINITION. Maximum density is defined as the maximum dry weight in pounds per cubic foot obtained when a material is mixed with different percentages of water and compacted in a standard manner as described in this specification. The percentage of water at which maximum density is obtained represents the moisture content necessary to give maximum compaction.

611-3.2 APPARATUS. The apparatus shall conform to the requirements of A. A. S. H. O. Method T-99 without any changes.

611-3.3 MATERIAL. The material to be used in this test shall be that portion of the sample passing the No. 4 mesh sieve.

611-3.4 PROCEDURE. The procedures and computations to determine maximum density shall be in accordance with A. A. S. H. O. Method T-99. The same sample of soil shall be used for the entire test unless the sample shows a tendency to pulverize or break down during the compaction process.

MAXIMUM DENSITY TEST FOR COARSE-GRADED MATERIALS

(Classes 3, 4, and 5 Airports)

611-4.1 DESCRIPTION. This item covers a method of determining the maximum density of materials having an appreciable percentage retained on the No. 4 mesh sieve by applying a correction factor to the maximum density of the portion of the sample passing the No. 4 mesh sieve. Use of this method is restricted to materials for base course and subbase construction.

611-4.2 PROCEDURE. (a) Determine the maximum density of the portion of the sample passing the No. 4 mesh sieve in accordance with the methods outlined in Section 2 above.

(b) Determine the apparent specific gravity of the coarse aggregate (material retained on the No. 4 mesh sieve) in accordance with A. A. S. H. O. Method T-85.

(c) Compute the theoretical density of the coarse aggregate by multiplying the apparent specific gravity by 62.36.

611-4.3 CORRECTED MAXIMUM DENSITY. The maximum density of the total sample shall be computed by the following formula:

$$D = \frac{P_r \times D_r}{100} + \frac{P_c \times 0.90 D_c}{100}$$

Where D = Maximum dry density of total sample in pounds per cubic foot.

D_r = Maximum dry density of portion of sample passing the No. 4 mesh sieve in pounds per cubic foot.

D_t = Theoretical density of portion of sample retained on the No. 4 mesh sieve in pounds per cubic foot.

P_r = Percentage of total sample passing the No. 4 mesh sieve.

P_c = Percentage of total sample retained on No. 4 mesh sieve.

MAXIMUM DENSITY TEST FOR COARSE-GRADED MATERIALS (Classes 1 and 2 Airports)

611-5.1 DESCRIPTION. This item covers a method of determining the maximum density of materials having an appreciable percentage retained on the No. 4 mesh sieve by applying a correction factor to the maximum density of the portion of the sample passing the No. 4 mesh sieve. Use of this method is restricted to materials for base course and subbase construction.

611-5.2 PROCEDURE. (a) Determine the maximum density of the portion of the sample passing the No. 4 mesh sieve in accordance with the requirements of A. A. S. H. O. Method T-99 without any changes.

(b) Determine the apparent specific gravity of the coarse aggregate (material retained on the No. 4 mesh sieve) in accordance with A. A. S. H. O. Method T-85.

(c) Compute the theoretical density of the coarse aggregate by multiplying the apparent specific gravity by 62.36.

611-5.3 CORRECTED MAXIMUM DENSITY. The maximum density of the total sample shall be computed by the following formula:

$$D = \frac{P_r \times D_r}{100} + \frac{P_c \times 0.90 D_t}{100}$$

Where D = Maximum dry density of total sample in pounds per cubic foot.

D_r = Maximum dry density of portion of sample passing the No. 4 mesh sieve in pounds per cubic foot.

D_t = Theoretical density of portion of sample retained on the No. 4 mesh sieve in pounds per cubic foot.

P_r = Percentage of total sample passing the No. 4 mesh sieve.

P_c = Percentage of total sample retained on No. 4 mesh sieve.

FIELD DENSITY TEST

611-6.1 DEFINITION. Field density refers to the density, expressed in pounds per cubic foot, of a layer of compacted material as determined on a sample representative of the compacted layer and tested as described in these specifications. For coarse graded subbase and base coarse materials this density shall include the weight of

the entire sample. When the compacted layer consists principally of soil material, the density shall be adjusted to represent the density of the sample on the basis of one hundred (100) percent passing the No. 4 mesh sieve.

611-6.2 APPARATUS. The apparatus for sampling and testing shall consist of any devices or equipment that will remove the compacted material in a satisfactory manner and be adequate to determine the weight, volume, and moisture content of the material removed.

611-6.3 SAMPLING PROCEDURES. (a) Undisturbed samples or cores may be obtained by driving a tube sampler into the soil layer and withdrawing the tube with the sample of soil inside. The sample shall be trimmed to the exact volume of the sampling tube and the weight determined as described in Section 6.4. Care must be exercised to avoid disturbance of the soil. This method of sampling can be used only in fine-grained, cohesive soils that contain no coarse aggregate.

(b) The sampling procedure that is applicable to all types of materials is described as follows:

By means of a soil auger or other cutting tool, dig a hole to the full depth of the layer to be tested. The hole shall be not less than four (4) inches in diameter and shall be dug in such a manner that the material surrounding the hole is neither further compacted nor loosened. The test hole shall present as neat lines as may be practicable to obtain, and all material shall be removed from the hole and placed in a covered container to prevent loss of moisture.

This can best be accomplished by leveling off the surface of the layer at the location to be tested, setting in place a soil collecting tray (an open-top wooden or metal box approximately fifteen (15) inches square and three (3) inches high) having a circular opening in the center of not less than four and one-half (4½) inches and removing the sample through this opening. The circular opening in the tray serves as a guide and template for digging the hole while the tray collects the spillage from the auger or spoon used in transferring the loosened material from the test hole to the container.

611-6.4 WEIGHT AND MOISTURE CONTENT OF SAMPLE. (a) All material removed from the test hole shall be weighed as soon after removal as practical. The weight shall be recorded to the nearest one-hundredth (0.01) pound.

(b) When all material removed from the test hole passes the one (1) inch sieve, and not more than fifteen (15) percent is retained on the No. 4 mesh sieve, a representative sample weighing approximately one hundred (100) grams shall be taken and dried to constant weight and the moisture content determined. The weights shall be recorded to the nearest one-tenth (0.10) gram.

(c) In the case of coarse-graded aggregates or other materials that do not conform to requirements in paragraph (b) above, all the ma-

terial removed from the test hole shall be dried to constant weight and the moisture content determined.

(d) Moisture contents shall be computed to the nearest one-tenth ($\frac{1}{10}$) percent by the following formula:

$$\text{Percent Moisture} = \frac{\text{Wt. of Wet Material} - \text{Wt. of Dry Material}}{\text{Wt. of Dry Material}} \times 100$$

(e) Dry weight of total sample may be computed by the following formula:

$$\text{Dry weight of total sample} = \frac{\text{Wet Weight of Total Sample}}{1 + \frac{\text{Percent Moisture}}{100}}$$

611-6.5 VOLUME OF SAMPLE. In the case of an undisturbed sample obtained with a tube sampler the volume of the sample is equal to the volume of the sampling device and no further test is required. The volume of samples secured by means of an auger or other cutting device is determined by measuring the volume of the hole from which the sample was removed. Three acceptable methods of making the determination are described as follows:

(a) *Sand Method.* This method consists of measuring the volume of the test hole by filling it with sand of predetermined weight per unit volume. A simple and accurate device for this purpose is a large jar fitted with a funnel and valve which is screwed onto the jar in place of the usual jar cover. The flared end of the funnel should be approximately six (6) inches in diameter.

Any clean sand having rounded particles all of one size (usually passing the No. 20 mesh sieve and retained on the No. 30 mesh sieve) may be used in this test. Standard Ottawa sand may be used but is not required. The sand must be dry when used, as damp sand is subject to bulking.

The volume of the jar is measured by filling the apparatus with water, closing the valve, pouring off the water retained in the funnel, and weighing. This weight minus the weight of the empty apparatus is the weight of water in the jar. The volume of the jar is equal to the weight of the water divided by 62.36, the weight per cubic foot of water.

After the volume of the jar is known the weight of sand required to fill it shall be determined as follows:

Place the apparatus, with valve closed and funnel up, on a table or other vibrationless support and fill the funnel with the sand to be calibrated. Then open the valve and pour more sand into the funnel, maintaining the sand in the funnel level with the top at all times. When the jar and funnel are full, close the valve and pour the sand from the funnel.

The weight of sand in the jar is determined by obtaining the difference in weight of the full and empty apparatus. This weight divided by the volume of the jar, previously determined with water, gives the weight per cubic foot of the sand under standard flow conditions.

To calibrate the constant weight of dry sand contained in the funnel, the weighed apparatus filled as described above shall be inverted on a smooth surface, the valve opened, and sand allowed to flow into the funnel until full. The difference between the weight of the apparatus with the remaining sand and the weight of the apparatus full of sand gives the weight of the sand in the funnel.

Once the sand and apparatus have been calibrated the volume of the test hole is determined by placing the apparatus in an inverted position (funnel down) over the hole, opening the valve, and allowing the sand to flow until the hole and funnel are completely filled. The valve is then closed and the apparatus with the sand remaining in it weighed. The difference between this weight and the weight before filling the hole is the weight of sand in the hole and funnel. By subtracting the constant weight of the sand in the funnel, the weight of sand required to fill the hole is found.

The volume of the sample is computed by the formula:

$$\text{Volume of sample} = \frac{\text{Weight of sand required to fill hole}}{\text{Weight per cubic foot of sand}}$$

(b) *Oil Method.* This method consists of measuring the volume of the test hole by filling with a heavy lubricating oil (S. A. E. 30 or 40) of a predetermined weight per unit volume. The weight per cubic foot of the oil may be found by weighing a measured quantity or by computing it from the specific gravity if known.

A 3-gallon can with a pouring spout is all the apparatus needed for filling the hole. Weights and volumes are determined in the same manner as by the sand method. The oil is removed from the hole by means of a suction gun and may be used until it becomes contaminated with soil particles to the extent that the unit weight may be changed.

(c) *Rubber-Sack Method.* This method consists of lining the test hole with a thin pliable rubber sack and filling the sack with water until the water is flush with the top of the hole. The volume of water may be measured directly if it is poured from a container calibrated for volume, or the weight may be determined as in the oil method and the volume found by dividing the weight of water by 62.36.

The volume occupied by the rubber sack must be determined accurately and corrections for its volume made in the readings taken.

It may be necessary to devise a means of applying air pressure in order to insure the filling of the entire space from which the sample was removed.

611-6.6 DENSITY. When the entire sample removed from the hole passes the No. 4 mesh sieve, the dry density may be determined from the following:

$$\begin{aligned} \text{Wet weight per cubic foot} &= \frac{\text{Weight of material removed from hole}}{\text{Volume of hole}} \\ \text{Dry weight per cubic foot} &= \frac{\text{Wet weight per cubic foot}}{1 + \frac{\text{Percent moisture}}{100}} \end{aligned}$$

These formulas also may be used to compute the density of coarse-graded materials whose maximum density has been determined as described in Sections 4 and 5.

For soils containing coarse material the weights, volumes, and resulting densities must be corrected in proportion to the amount of material retained on the No. 4 mesh sieve. This correction is applied in order to put the field density on the same basis as the maximum density determined on the portion of the sample passing the No. 4 mesh sieve in accordance with Sections 2 and 3. Inclusion of material larger than the No. 4 mesh sieve would have the effect of increasing this density owing to the higher specific gravity of the coarse aggregate as compared to the bulk specific gravity of the compacted soil. Therefore, corrections to weight and volumes shall be made in the following manner:

After the dry weight of the material removed from the hole has been determined, the total sample shall be separated on the No. 4 mesh sieve and that portion retained shall be thoroughly cleaned and weighed. The weight of the dry coarse aggregate subtracted from the dry weight of the total sample, determined as described in Section 6.4, gives the dry weight of the material passing the No. 4 mesh sieve.

To determine the volume of the portion of the sample passing the No. 4 mesh sieve, one of the three following methods shall be used:

(a) When the coarse aggregate portion of the sample removed from the test hole amounts to fifteen (15) percent or less of the total sample, and when the sand or oil method is used to determine the volume of the hole, the coarse material may be placed back in the hole and the volume of the hole determined by filling with sand or oil after the coarse aggregate has been replaced.

If the coarse material comprises more than fifteen (15) percent of the total sample, the volumes shall be adjusted as described in paragraphs (b) and (c) below.

(b) Determine the volume of the surface dry coarse aggregate directly by immersing in a liquid and measuring the volume of the displaced liquid. The volume of coarse aggregate subtracted from the volume of the test hole gives the volume of the portion of the sample passing the No. 4 mesh sieve.

(c) Determine the apparent specific gravity in accordance with A. A. S. H. O. Method T-85. Compute the theoretical density by multiplying the apparent specific gravity by 62.36. Divide the dry weight of coarse aggregate by the theoretical density to obtain the volume of the coarse aggregate. The volume of coarse aggregate subtracted from the volume of the test hole gives the volume of the portion of the sample passing the No. 4 mesh sieve.

The density of the compacted layer, corrected to the density of the portion of the sample passing the No. 4 mesh sieve, is computed by the following:

$$\text{Dry weight per cubic foot} = \frac{\text{Dry weight of fraction passing the No. 4 mesh sieve}}{\text{Volume of fraction passing the No. 4 mesh sieve}}$$

PERCENT COMPACTION

611-7.1 DEFINITION. Percent compaction is defined as the density of the compacted layer expressed as a percentage of the maximum density of the material when tested in accordance with these specifications.

611-7.2 COMPUTATIONS. The percentage of compaction is computed by the formula:

$$\text{Percent compaction} = \frac{\text{Field density}}{\text{Maximum density}} \times 100$$

The procedure in conducting the test is to oven-dry the sample to constant weight. To 600 grams of the oven-dried material, with all lumps broken up, is added 10.5 cc. of water; then mix uniformly. The cup is filled with the sample material. A bearing plate covering the sample is placed and an initial pressure, by hand, is given the bearing plate. The plate is removed and material is heaped up in the cup. The bearing plate cover is again placed on the material and hand pressure applied. The excess above the top of the cup is removed and a total pressure of 1,200 pounds is applied. The large bearing plate is then removed and the small bearing plug of one (1) square inch area is placed in the center of the cup testing lightly on the surface of the material. The lever arm of the machine is then leveled and balanced. The test is made by applying a constant increasing load by allowing the water to run from the funnel into the bucket until the pressure on

TEST T-607 SAND STABILITY TEST

The sand stability test is conducted by means of a machine which was developed and patterned after the one described in "Public Roads," Vol. 6, No. 4, April 1925, Page 38, except the lever arm system was changed to a single straight lever arm. The equipment consists of a four-legged stand on which is mounted a lever arm and a sand-bearing cup. On one end of the lever arm is a counterbalance, and on the other end is a bucket suspended by a spring balance graduated in pounds. The load is applied to the lever arm by water which is allowed to run from the funnel, mounted on a leg of the stand, into the bucket. In the middle of the stand is mounted, on an adjustable screw, the base for the sand cup. This cup is three (3) inches in diameter and three (3) inches deep. Directly over the center of this base a small ball bearing is welded to the underside of the lever arm. The purpose of this ball bearing is to transfer the load from the lever arm through a small circular bearing plug to the sample in the sand cup. The ball bearing is usually placed at one-fourth the distance from the lever arm fulcrum to the knife edge on the end of the arm from which the spring balance is suspended. This method gives a lever arm ratio of four (4) for the machine. The bearing plug is circular, has a bearing face of one (1) square inch, and has a socket in the center of its top surface into which can fit the ball bearing. Before the loading test is started, the lever arm can be leveled by the screw adjustment on the sand cup base, and can be balanced by the counterweights on the end of the arm. A bearing plate is provided which is approximately three (3) inches in diameter and which will fit into the cup to compress the sample before the test is made.

The procedure in conducting the test is to oven-dry the sample to constant weight. To 600 grams of the oven-dried material, with all lumps broken up, is added 10.5 cc. of water; then mix uniformly. The cup is filled with the sample material. A bearing plate covering the sample is placed and an initial pressure, by hand, is given the material. The plate is removed and material is heaped up in the cup. The bearing plate cover is again placed on the material and hand pressure applied. The excess above the top of the cup is removed and a total pressure of 1,200 pounds is applied. The large bearing plate is then removed and the small bearing plug of one (1) square inch area is placed in the center of the cup resting lightly on the surface of the material. The lever arm of the machine is then leveled and balanced. The test is made by applying a constant increasing load by allowing the water to run from the funnel into the bucket until the pressure on

The bearing plug is great enough to upset the stability of the sample. At failure the load, as indicated by the spring balance, is recorded. The load or the stability is in pounds and is calculated by multiplying the balance reading by four (4) or by the figure which is the lever arm ratio of the machine.

The above stability test was originated and developed by the Florida State Road Testing Department. As mentioned above, the soil-bearing machine of the Public Roads Administration was used as a model. This test has been adopted by many State highway departments which include sand asphalt pavements in their highway specifications and is recommended for a method of predetermining the suitability of sand aggregate for bituminous mixtures.

In addition to the application of the stability test to sands that do not comply with specified gradations, this test may be utilized to check the stability of the matrix of any accepted mixtures. In such cases the test should be conducted on that portion of the mineral aggregate which passes the No. 10 mesh sieve. In all instances, the stability test should be conducted at one and three-fourths (1 3/4) percent moisture content which is obtained from measurements given above.

A small ball bearing is welded to the underside of the lever arm. The purpose of this ball bearing is to transfer the load from the lever arm through a small circular bearing plug to the sample in the sand cup. The ball bearing is usually placed at one-fourth the distance from the lever arm fulcrum to the knife edge on the end of the arm from which the spring balance is suspended. This method gives a lever arm ratio of four (4) for the machine. The bearing plug is circular, has a bearing face of one (1) square inch, and has a socket in the center of its top surface into which can fit the ball bearing. Before the loading test is started, the lever arm can be leveled by the screw adjustment on the sand cup base, and can be balanced by the counterweights on the end of the arm. A bearing plate is provided which is approximately three (3) inches in diameter and which will fit into the cup to compress the sample before the test is made.

The procedure in conducting the test is to oven-dry the sample to constant weight. To 600 grams of the oven-dried material, with all lumps broken up, is added 10.5 cc. of water; then mix uniformly. The cup is filled with the sample material. A bearing plate covering the sample is placed and an initial pressure, by hand, is given to the material. The plate is removed and material is heaped up in the cup. The bearing plate cover is again placed on the material and hand pressure applied. The excess above the top of the cup is removed and a total pressure of 1,200 pounds is applied. The large bearing plate is then removed and the small bearing plug of one (1) square inch area is placed in the center of the cup resting lightly on the surface of the material. The lever arm of the machine is then leveled and balanced. The test is made by applying a constant increasing load by allowing the water to run from the funnel into the bucket until the pressure on

INDEX

	Page
Abbreviations.....	1
Abrasion Test..... 119, 125, 132, 141	141
Acceptance and Final Payment..	33
Acceptance of Materials.....	17
Adjustments of Contract Time...	26
Adjustment of Suspended Work..	27
Admixtures.....	353
Advertisement for Bids.....	6
Aggregates (see particular construction item):	
Coarse	
abrasion..... 35, 119, 125, 288	288
gradation table.....	39
stabilizer.....	209
Fine:	
concrete pavement.....	289
concrete structures.....	342
sand asphalt..... 96, 236	236
Agreement, supplemental.....	12
Airport:	
definition.....	1
Alteration of Plans.....	12
Altered Quantities.....	12
American Association of State Highway Officials.....	1, 35
American Society of Testing Materials.....	1, 35
Amount of:	
contract bond.....	10
performance bond.....	10
proposal guaranty.....	7
Annulment of contract.....	27
Approval of materials of contract.	17, 34
Asphalt (see "Bituminous Materials").	
Asphalt Concrete Surface Course.	268
Assignment of Contract.....	24
Authority of Engineer.....	15
Authority of Inspector.....	17
Award of Contract.....	10
Backfilling:	
ducts.....	524
pipe, drainage..... 360, 366, 705	705
structures..... 394, 398, 404	404
underdrains.....	386
Bars:	
dowels..... 36, 292	292
tie..... 36, 292	292
reinforcement..... 36, 292, 345	345
Barricades and Warning Signs..	21, 313
Base Courses:	
Bituminous:	
emulsion—aggregate.....	184
hot plant mix.....	93
penetration macadam.....	176
travel plant..... 108, 197	197
Nonbituminous:	
aggregate..... 131, 141	141
caliche.....	148
crushed aggregate.....	141
dry-bound macadam.....	119
lime rock.....	156
sand-clay.....	169
shell.....	162
water-bound macadam.....	125

	Page
Basins, Catch.....	390
Batching Material.....	298, 347
Beacon:	
code.....	46, 477
installation..... 472, 477, 536	536
rotating.....	45, 472
tower.....	46, 481
Beginning Work.....	24
Bid:	
bonds.....	7
consideration of.....	10
definition.....	3
guaranty.....	3
Bidder:	
competency of.....	8
definition of.....	1
disqualification.....	8
financial resources.....	8
qualifications.....	8
Bid Schedule:	
contents.....	6
form.....	7
Bins:	
batching..... 98, 238, 298	298
storage..... 98, 188, 237	237
Bituminous Base Course:	
emulsion—aggregate.....	184
hot plant mix.....	93
penetration macadam.....	176
travel plant..... 108, 197	197
Bituminous Distributor.....	316
Bituminous Material:	
Asphalt:	
cement..... 37, 95, 235	235
90 + material..... 37, 250, 334	334
cut-back, rapid-curing. 37, 110, 323	323
cut-back, medium-curing... 37, 315	315
emulsified..... 38, 110, 178, 186	186
Tar..... 37, 95, 110, 315	315
Bituminous Plants:	
Central:	
base courses..... 97, 188	188
surface courses..... 237, 258, 271	271
Traveling:	
base courses..... 112, 201	201
Bituminous Prime Coat.....	315
Bituminous Seal Coat.....	322
Bituminous Surface Courses:	
asphalt concrete, liquefier....	268
blended limestone and sand... 255	255
hot plant mix.....	233
Surface Treatment.....	332
blended limestone and sand..	280
Bituminous Tack Coat.....	318
Blasting.....	56
Bonds:	
bid.....	7
contract.....	10
payment.....	10
Borrow Excavation.....	56
Bracing..... 359, 365, 372	372
Brick Masonry.....	392
Bulk Cement..... 291, 343	343
Burlap Curing.....	305

	Page		Page
Cable:		Concrete, Structures:	
installation.....	505, 555	aggregates.....	35, 341, 342
markers.....	508, 558	composition.....	345
testing.....	509, 559	curing.....	350
underground.....	47, 505, 555	forms.....	348
Calcium Chloride.....	345, 353	joints.....	349
Caliche Base Course.....	148	Conduits:	
Cast Iron Pipe.....	41, 375	electrical.....	47, 472, 497, 566
Catch Basins.....	390	fiber.....	47, 497
Cement:		steel.....	497
Portland.....	35	Consideration of Bid.....	10
high early.....	35	Consistency:	
air entrained.....	35	concrete pavement.....	299
rubble masonry.....	401	concrete structures.....	347
soil—base course.....	216	Construction:	
Central Mixing Plants.....	97, 237	joints.....	104, 244, 310
Certified Checks for Bids.....	7	stakes.....	16
Character of Workmen.....	24	Construction Methods:	
Claims:		bituminous construction.....	97, 237
disputed, for extra work.....	19	flexible paving.....	120, 143, 176
Cleaning Up:		Contents of Proposal Forms.....	
final.....	14	Contract:	
Clearing and Grubbing.....	50	approval.....	11
Coarse Aggregate:		annulment.....	27
table.....	39	assignment.....	24
Cold Weather Concreting.....	308, 351	award of.....	10
Common Excavations.....	53	bond.....	10
Compaction:		execution of.....	11
aggregate base.....	138	failure to execute.....	11
bituminous mix.....	103, 115, 204	fulfillment of.....	29
control tests.....	570	subletting.....	24
crushed aggregate base.....	145	time of completion.....	24
embankments.....	58	time of extensions.....	26
emulsion—aggregate mix.....	193	Contractor:	
travel plant mix.....	115, 204	cooperation of.....	15
Competency of Bidders.....	8	definition of.....	2
Completion of Project:		notice to.....	6
failure to complete on time.....	26	responsibility for work.....	23
seasonal work.....	28	Control of Work.....	15
Completion of Work:		Convenience and Safety of Pub-	
extension of time.....	26	lic.....	21
failure to.....	26	Corrugated Metal Pipe.....	41, 369
Concrete Base:		Crushed Aggregate Base Course.....	141
lean-mix rolled.....	224	Culverts:	
Concrete Culverts.....	397	cast iron pipe.....	41, 375
Concrete Headwalls.....	397	concrete box.....	397
Concrete Curb.....	407	concrete pipe.....	40, 363
Concrete Gutter.....	407	corrugated metal pipe.....	41, 369
Concrete Pavement:		vitrified pipe.....	40, 357
aggregates.....	35, 288, 289	Curing:	
batching plant.....	298	concrete pavement.....	306
class A.....	295	concrete structures.....	350
class B.....	296	Cuts—Excavation.....	54
class C.....	296	Damage Claims.....	22
curing.....	305	Decreased Quantities of Work.....	12
dowels and tie bars.....	36, 292, 309	Definition of Terms.....	1
forms.....	294	Delivery of Proposal.....	7
joints.....	308	Disposal:	
opening to traffic.....	313	ditch material.....	57, 361
reinforcement.....	36, 292, 312	excavation material struc-	
subgrade.....	293	tures.....	394, 399
testing surface.....	312	structures.....	13, 51
vibrators.....	304	surplus material.....	14, 53, 404
water.....	36, 292, 299	Disqualification of Bidders.....	8
Concrete Pipe:		Ditch, Drainage Excavation.....	57
culverts.....	40, 363	Dowel Bars:	
storm sewer.....	40, 363	in expansion joints.....	36, 309
underdrains.....	40, 381		

	Page		Page
Drainage:		Fabricated Bar Mats	36, 292
definition.....	2	Failure:	
ditch excavation.....	57	to complete work.....	26
pipe.....	40, 357, 363, 369	to execute contract.....	11
structures.....	41, 390	Fence:	
Drains, Under	381	class A.....	40, 71
Drawings and Plans	3, 6, 12, 15	class B.....	40, 71
Ducts:		class C.....	40, 77
backfilling.....	524	class D.....	40, 77
electrical.....	47, 521	class E.....	40, 82
Installation:		class F.....	40, 89
asbestos cement.....	521	Fertilizer	43, 412, 426, 435, 447
fiber.....	521	Fertilizing	415, 429, 438, 450
in concrete.....	522	Field Office	16
terra cotta.....	521	Filler:	
markers.....	524	joint.....	37, 292, 327
Duties of Inspectors	17	mineral.....	38, 95
Edging	303	Final:	
Embankments:		acceptance.....	33
compaction.....	58	cleaning up.....	14
layers.....	58	estimate.....	33
preparation for.....	57	inspection.....	33
placing rock.....	59	payment.....	33
Emulsified Asphalt	38	Fine Grading	60
Emulsified Asphalt Aggregate		Finished:	
Base Course.....	184	grading.....	61
Engineer:		surface.....	245, 265, 278, 312
authority of.....	15	tolerance.....	61, 105, 122, 146
definition of.....	2	Finishing:	
Equipment:		concrete pavement.....	301
approval of.....	25	structures.....	350
character of.....	25	Float:	
Establishment of Turf	412	longitudinal.....	302
Estimates:		Footings:	
interpretation.....	6	depth of.....	391, 397
quantities.....	6	excavation.....	391, 397
Examination of Plans and Specifications:		headwalls.....	397
of special provisions.....	6	lowering.....	391, 397
of site of work.....	6	structures.....	391, 397
Excavated Material Disposal	53, 54	Force Account Work:	
Excavation:		payment for.....	31
benching.....	57	Forms:	
borrow.....	56	concrete pavements.....	294
classification.....	53	concrete structures.....	348
common.....	53	soil cement base.....	218
drainage ditch.....	57	Foundation:	
foundation.....	391, 397	excavation.....	391, 397
haul.....	61	inspection.....	392, 398
muck.....	58	Fulfillment of Contract	29
pipe.....	358, 364, 370	Galvanized:	
rock.....	55	fence.....	71, 77, 82
stripping.....	58	pipe.....	369
structures.....	391, 397	Gates for Fences	71, 77, 83, 91
unclassified.....	53	Gauge:	
underdrain.....	383	pipe.....	369
Execution of Contract	11	wire fence.....	71, 77, 82
failure to.....	11	General Provisions	1
Expansion Joints	292, 309	Grading and Excavation	53
Expansion Joints Filler:		Grass (see "Seeding," "Overseed-	
concrete pavements.....	37, 292	ing," "Sprigging," "Sodding,"	
structures.....	345	"Topsoil Planting").....	412
Explosives, Use of	21	Gravel Base	131
Extra:		Gray Iron Castings	390
depth excavation.....	391, 397	Grounding:	
strength pipe.....	357, 363, 375	electric.....	488, 518, 531
work.....	13	Grubbing and Clearing	50

	Page		Page
Guaranty:		Legal Rights:	
material.....	9	no waiver of.....	23
performance.....	10	License and Permits.....	20
proposal.....	7	Lighting.....	472 to 569
Gutters.....	407, 410	Lights:	
Guying.....	461	cone-mounted.....	491
Hand Finish:		Elevated marker:	
concrete pavements.....	303	base-mounted.....	540
Handling:		column-mounted.....	548
aggregates.....	17, 295	stake-mounted.....	544
cement.....	290	flush marker.....	486
reinforcement.....	313	installation.....	486, 491, 540, 565
Haul, Excavation.....	61	obstruction.....	496, 561
High Early Strength:		Runway Marker:	
cement.....	35, 290	high-intensity.....	540, 544, 548
concrete.....	290, 344	Lime Rock Base Course.....	156
Holes, Test:		Limestone and Sand:	
for base thickness..	122, 138, 146, 167	asphalt surface course.....	251
Hoppers:		Liming.....	415, 429, 438, 450
aggregate.....	98, 238, 298	Limits, Shown on Plans.....	15
Hydrated Lime.....	38	Liquefier.....	38, 270
Increased Depth of Footings...	391, 397	Longitudinal Float.....	302
Increased Quantities of Work...	12	Liquid Limit.....	133, 142, 148, 170
Inlets and Catch Basins.....	390	Lumber:	
Inspection:		forms.....	218, 348
by engineer.....	18	Macadam:	
final.....	33	dry-bound.....	119
materials.....	17	penetration.....	176
pipe.....	361, 367, 373	water-bound.....	125
Portland cement.....	224	Machine Finishing:	
Inspector:		concrete pavement.....	304
authority of.....	17	Machine Mixing:	
definition of.....	2	pavements.....	299
duties of.....	17	Machining and Compacting:	
Intent of Plans and Specifications.....	12	bases.....	138, 145, 166, 173
Interpretation of Estimates.....	6	embankments.....	58
Iron Castings and Fittings:		Maintenance:	
gray.....	41, 390	detours.....	13
malleable.....	41, 390	drainage ditches.....	57
Isolated Trees.....	50	embankments.....	59
Items, Omitted.....	13	pavements.....	117, 139, 146, 174
Job Mix.....	93, 108, 184, 233	traffic.....	13
Joints:		Malleable Iron Castings.....	41, 390
construction.....	308	Manholes.....	390
contraction.....	309	Marking:	
expansion.....	309	ducts.....	524
longitudinal.....	245, 310	equipment.....	517
transverse.....	244, 309	pipe (see "Pipe Specs.")	
Joint Fillers:		Masonry:	
asphalt.....	37, 292	backfilling.....	394
hot poured.....	327	brick.....	392
premoulded.....	37, 292	cement rubble.....	401
rubber and cork.....	37	excavation.....	391, 402
tar.....	37, 292	Materials:	
wood.....	37	approval.....	17, 34
Jute Mats.....	306	aggregates.....	35, 38
Laboratory:		bituminous.....	37, 38
definition of.....	2	defective.....	18
tests.....	17	found on the work.....	14
Lamps, Electrical.....	489	guaranty.....	9
493, 500, 504, 554, 563		patented.....	20
Laws to be observed.....	20	quality of.....	34
Laying Brick.....	392	samples and tests.....	17
Laying Sod.....	439	source of supply.....	16
Legal Relations.....	20	storage.....	17
		Mat, Key Stone.....	248
		Mats:	
		bar.....	36, 292
		cotton or jute.....	306

	Page		Page
Measurement of Quantities.....	30	Permits and License.....	20
Mechanical Tampers.....	61, 360, 398	Pipe:	
Mesh, Wire.....	36, 292, 345	bituminous coated corrugated	
Metal:		metal.....	41, 369
for corrugated metal pipe....	41, 369	backfilling.....	360, 366, 372, 378, 386
galvanized for fences.....	40, 77, 83	cast iron.....	41, 375
posts for fences.....	40, 78, 83	clay.....	40, 357
wire for fences.....	40, 71, 77, 82	concrete.....	40, 363
Mineral Fillers.....	38	construction methods.....	358,
Mixer:		364, 370, 383	
central plant.....	99, 239	corrugated metal.....	41, 369
concrete.....	299	culvert.....	357, 363, 369, 375
traveling.....	112, 201	perforated.....	40, 41, 381, 382
truck.....	300	plain and reinforced concrete..	40, 363
Mixing:		underdrains.....	381
base materials.....	135, 144, 171	vitrified clay pipe.....	40, 357
concrete.....	299	Plans and Drawings:	
Mortar:		conformity with.....	15
brick.....	41, 390, 392	coordination of.....	15
pipe.....	360, 366, 378, 385	definition of.....	3
rubble masonry.....	402	examination of.....	6
sand.....	357, 383, 390	intent of.....	12
Motor Grader.....	201, 282	Plant:	
Mowing.....	417, 432, 440	inspection.....	105, 195, 245
Muck Excavation.....	58	paving, bituminous.....	97, 188, 237
Mulching.....	457	Planting Sprigs.....	430
		Planting Trees, Shrubs, and Vines.	460
Naphtha, Liquefier.....	38, 270	Poles:	
Notice to Begin Work.....	3, 24	lighting.....	497, 561
Notice to Contractors.....	6	Portland Cement:	
Officials, Personal Liability of....	23	pavement.....	288
Omitted Items.....	13	storage of.....	17, 290, 343
Opening to Traffic.....	23, 313	structures.....	341
Optimum Moisture.....	58	Posts:	
Orders:		Fence:	
change.....	31	steel.....	40, 78, 83
extra work.....	13	wood.....	40, 72, 89
Overhaul.....	61	Premoulded Joint Filler ..	37, 292, 345
Overseeding.....	421	Preparation of Proposal.....	7
		Preparing Ground Surface for	
Pads:		Turf.....	415, 422, 428, 437
concrete.....	487, 492, 541	Prequalification of Bidders.....	8
Paper Curing:		Prime Coat:	
concrete.....	306, 350	bituminous.....	315
Paint:		Project:	
bituminous.....	391, 484	definition.....	3
metal.....	473, 481, 502, 512	final acceptance.....	33
white lead.....	473, 482, 503, 537	Proposal:	
white.....	90	consideration.....	6
Partial Payments.....	32	delivery.....	7
Patent Devices.....	20	form.....	6
Pavements Samples.....	105, 245, 265	guaranty.....	7
Payment:		preparation of.....	7
Bond.....	10	public opening.....	8
Extra or force account work....	31	requirements and conditions... 6	
final.....	33	rejection.....	7
increased and decreased quanti-		withdrawal.....	8
ties.....	31	Prosecution of Work.....	24
omitted items.....	31	Protection:	
partial.....	32	of property.....	22
scope of.....	30	concrete pavement.....	305, 306
Penetration:		Pruning.....	466
bituminous material.....	37	Public Convenience and Safety..	21
Penetration Macadam:		Pug Mill.....	99, 239
base.....	176	Quality of Material.....	17, 34
materials.....	177	Quantities:	
Perforated Pipe:		increased and decreased.....	12
clay.....	40, 381	payment for.....	30
concrete.....	41, 382	measurement of.....	30
metal.....	41, 382	Quarries.....	120, 126, 143

	Page		Page
Ready Mixed Concrete.....	299, 347	Shell Base Course.....	162
Reinforced Concrete:		Sheepsfoot Rollers.....	60, 218
pavement.....	288	Shoulders:	
pipe.....	363	definition of.....	4
Reinforcement:		seeding.....	412
bars.....	36, 292, 345	Shrubs (see Planting Trees,	
bar mats.....	36, 292, 312	Shrubs and Vines).....	460
placing.....	313, 348	Signature of Proposal.....	7
splices.....	313	Signs, Warning.....	21
weights.....	36	Site of Work:	
wire mesh.....	36, 292, 345	examination of.....	6
Rejection of Proposal.....	7	Slag.....	38, 94
Requirements:		Slides and Overbreaks.....	55
contract bond.....	10	Slopes, Excavation.....	56
foreign corporation.....	9	Smooth Grading, Turfing.....	415,
payment bond.....	10	423, 429, 438	
Resident Engineer:		Sodding.....	435
definition of.....	2	Soil Cement Base Course.....	216
duties.....	15	Soil Type Base Course.....	169
Responsibility for:		Solid Rock:	
damage claims.....	22	classification.....	53
work.....	23	Excavation:	
Right of Way:		for pipe.....	358, 364, 371, 383
definition.....	3	in subgrade.....	55
Road, Access:		Sources of Supply of Materials...	16
definition.....	1	Sowing Seed.....	416, 423
Rock (see "Solid Rock")		Special Provisions:	
Rolled Concrete Base Course....	224	coordination of.....	15
Rollers:		definition of.....	4
for bituminous mixtures. 100, 113, 240		examination of.....	6
for bituminous seal.....	324	Special Work.....	12
pneumatic tired.....	113, 324	Specifications:	
power.....	100, 120, 179	coordination of.....	15
sheepsfoot.....	60, 218	definition of.....	4
Rolling:		examination of.....	6
bituminous-pavements.....	103,	intent of.....	12
115, 243, 277		Spelter Coat:	
embankments.....	58	fence post and wire.....	71, 77, 84
subgrade.....	60	corrugated metal pipe.....	369
Root Protection.....	469	Spillways.....	407, 410
Rubble Masonry.....	401	Splicing:	
Runways:		fences.....	75, 80, 86
definition.....	4	reinforcing bars.....	313
Safety and Convenience to Public. 21		reinforcing mesh.....	313
Salvaged Topsoil.....	62, 444	cables.....	508, 557
Sampling and Testing:		Spreader:	
aggregates.....	17, 34	chip.....	179, 324
materials.....	17, 34	Sprigging.....	426
Sand:		Stability Test:	
for concrete.....	289, 342	sand.....	578
for mortar.....	357, 363, 383, 390	Stabilizer Aggregate.....	209
stability test.....	578	Stakes, Construction.....	16
Sand Asphalt Base.....	93, 96	Steel:	
Sand Asphalt Surface.....	233, 236	pipe, corrugated.....	41, 369
Sand Asphalt and Limestone Sur-		posts, fence.....	78, 83
face.....	251	reinforcement.....	36, 292, 345
Sand-Clay Base Course.....	162	Stock piles:	
Sanitary Provisions.....	21	aggregates.....	295
Scales:		Stone:	
for batching plant.....	98, 238, 298	gradation.....	39
for bulk cement.....	291	key stone mat.....	248
Scope of Payment.....	30	Storage:	
Scope of Work.....	12	cement.....	17, 290, 343
Seal Coat:		materials.....	17
bituminous.....	322	Stripping, Excavation.....	58
Seasonal Work:		Structures:	
completion of.....	28	definition.....	4
Seeding.....	412	Portland cement concrete...	390, 397
Setting Forms.....	218, 294, 348	removal.....	51
Setting Plants.....	465	Subbase Course.....	65

	Page		Page
Subcontractor.....	24	Turf—Aggregate Pavement.....	208
Subdrains.....	381	Unauthorized Work.....	18
Subgrade:		Unclassified:	
compaction.....	61	Excavation.....	53
definition.....	4	for structures.....	391
fine grading.....	293	Underdrains:	
preparation.....	60	backfill.....	386
Subletting Contract.....	24	excavation.....	383
Supplemental Agreement.....	12	pipe.....	381
Surety, Bond.....	7, 10	Unit Prices of Proposal.....	7
Surface Finish:		Use of:	
concrete pavement.....	301, 312	explosives.....	21
Smoothness:		material found on work.....	14
bituminous pavement.....	245, 265, 278	straightedge.....	105, 121, 127, 302
flexible bases.....	138, 146, 182		
Surface Treatment:		Vault:	
bituminous.....	332	transformer.....	511
key stone mat.....	248	Vehicles:	
blended limestone and sand		measurement in....	419, 425, 433, 441
asphalt.....	280	Vibrators:	
Surplus Material:		concrete.....	302, 304, 349
disposal.....	14, 53, 404	Vines (see "Planting Trees,"	
Suspension of Work:		"Shrubs and Vines").....	460
temporary.....	25	Vitrified Clay Pipe.....	357
Tack Coat:		Waiver of Legal Rights.....	23
bituminous.....	318	Walls:	
Tar (see "Bituminous Material").		head.....	397
Taxiways:		retaining.....	397
definition.....	4	Warning Signs.....	21
Testing:		Watchman.....	21
methods of.....	17, 35	Water:	
electrical installations.....	476, 493, 531	for bases.....	128, 138, 152, 173
Tests:		for concrete.....	36, 292, 344
compaction control.....	570	for embankments.....	58
stability, sand.....	578	for tests.....	36
Tie Bars.....	36, 292	Wearing Surfaces:	
Tilling.....	415, 455	bituminous.....	233, 251, 268
Time:		concrete.....	288
extension of.....	26	surface treatment.....	280, 332
failure to complete work on...	26	Weather Limitations:	
of completion.....	24	concrete.....	307, 351
Topsoil:		pavements.....	97, 179, 237, 271
excavation.....	62, 444	seal coat.....	324
planting.....	447	Weigh Boxes.....	98, 238, 298
salvage.....	62, 444	Weights:	
Topsoiling.....	443	bituminous.....	99, 239
Tower, Beacon.....	46, 481	aggregates for concrete.....	295, 346
Traffic:		corrugated metal pipe.....	369
opening to.....	23, 313	reinforcing bars.....	36, 312, 345
Transformer:		Welding:	
booster.....	504, 535, 538, 554	pipe.....	382
vault.....	511	grates.....	391
Transplanting.....	467	Wind Cone:	
Travel Plant.....	112, 201	installation.....	502, 552
Treatment:		Wind Tee:	
surface, bituminous.....	332	installation.....	533
Trees (see Planting Trees, Shrubs		Wire:	
and Vines).....	460	cable.....	505, 555
Tree Wells.....	469	electric.....	472, 513, 526, 552
Tree Wells and Root Protection..	469	fence.....	71, 77, 82
Trenches:		mesh.....	36, 292, 345
cable.....	506, 556	Wiring Building:	
duct.....	523	installation.....	526
Truck Mixers.....	300	Withdrawal of Proposal.....	8
Turf:		Wood Joint Filler.....	292
definition.....	4	Wood Post, fence.....	71, 89
Turfing (see "Seeding", "Sprig-		Work:	
ging", "Sodding", and "Top-		begin.....	24
soil Planting").....	412, 426, 534, 447	contractor's responsibility....	23

	Page
Work—Continued	
decreased quantities of.....	12
defective.....	18
extra.....	13
force account.....	13
failure to complete on time.....	26
increased quantities for.....	12
increased time for.....	26
prosecution of.....	24
seasonal.....	28
special.....	12
suspended, adjustment.....	27
temporary suspension of.....	25

	Page
Working Days:	
begin.....	24
definition.....	5
loss due to delay.....	26
not charged.....	26
Sundays and legal holidays.....	5
Working Drawings.....	15
Workmen, Character of.....	24
Workmanship:	
pavements.....	25
pipe.....	363, 369, 375
Wrapping.....	461, 467

Digitized by:



ASSOCIATION
FOR
PRESERVATION
TECHNOLOGY,
INTERNATIONAL

www.apti.org

BUILDING
TECHNOLOGY
HERITAGE
LIBRARY

<https://archive.org/details/buildingtechnologyheritagelibrary>

From the collection of:
Robert Vail Cole Jr, AIA
1962 – 2011

